34

Science Council of Canada Report

Transportation in a Resource-Conscious Future

Intercity Passenger Travel in Canada

Transportation in a Resource-Conscious Future

Intercity Passenger Travel in Canada

September 1982

Science Council of Canada
100 Metcalfe Street
17th Floor
Ottawa, Ontario
K1P 5M1

©Minister of Supply and Services, 1982

Available in Canada through

Authorized Bookstore Agents
and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Hull, Québec, Canada K1A 0S9

Vous pouvez également
vous procurer la version française,
Les transports et notre avenir énergétique – Voyages interurbains au Canada
à l'adresse ci-dessus

Catalogue No. SS22-1982/34E
ISBN 0-660-11201-9

Price: Canada: $4.95
Other countries: $5.95

Price subject to change without notice

September 1982

The Honourable Donald J. Johnston, PC, MP
Minister of State for Science and Technology
House of Commons
Ottawa, Ontario

Dear Mr. Johnston,
In accordance with Section 13 of the Science Council of Canada Act, I take pleasure in forwarding to you the Council's Report 34, *Transportation in a Resource-Conscious Future: Intercity Passenger Travel in Canada*.

Yours sincerely,

Stuart L. Smith
Chairman
Science Council of Canada

Contents

Preface	1
I. Growth to a Multimodal System	5
How the Transportation System Developed	6
Passenger Characteristics and Modal Attributes	7
How the Costs Compare	8
Subsidies for the Various Modes	10
Problems Facing the Transportation System in Canada	11
The Travel Alternative: Network of Newest Electronics	15
II. The Air Mode	17
The Flight from Yesterday to Today	18
How the Airlines Compare	19
Coping with the Oil Crisis	20
Applying the Remedies of the Past	22
Air Service and Transportation Policy	23
Aircraft of the Future	26
Developing the STOL	27
Private Aviation	29
Canadian Aerospace Industry	30
Recommendations	35
III. The Rail Mode	37
The Tarnished Ribbon	38

The Problem of Aging Equipment 40
Restrictions on Revenue 42
Keeping the Lid on Costs 43
The System Segments 44
A Rejuvenated Rail Service System 45
Recommendations 53

IV. The Auto Mode 55
The Ubiquitous Automobile 56
The Growth of the Auto Mode Since 1974 57
The Decline of the Auto Industry 58
The Changing Automobile and the Changing Fleet 59
The Canadian Auto Industry 61
The Independent Parts Manufacturers 64
The World Car 64
The Japanese Advantage 65
Automotive Employment 67
A Third Generation 69
A Better Canadian Future 69
Recommendations 73

V. The Bus Mode 75
The Evolution of the Bus Industry 76
The Passenger Market and the Service Provided 77
The Canadian Bus Manufacturing Industry 78
A Larger Bus Design 82
Design Options for Larger Buses 82
Size and Manoeuvrability Considerations 84
Industrial Opportunities 86
Recommendations 89

Appendices 91

Appendix 1 - Opportunities in Canadian Transportation: Study Documents 92

Appendix 2 - Other Science Council Publications Touching on Transportation 95

Notes 97

Index 99

Opportunities in Canadian Transportation Committee 103

Members of the Science Council of Canada 104

Publications of the Science Council of Canada 106

Tables

Table I.1 – One-Way Line Haul Fares, 1981 9

Table I.2 – Calculation of Transportation Subsidies, 1978-79 ($ in millions) 10

Table I.3 – Current Transportation Policy by Instruments, Modes and Governments 12

Table I.4 – Approximate Direct Energy Consumption by Mode 13

Table II.1 – Air Canada, CP Air and Regional Carrier Financial Data 21

Table II.2 – Effect of Changes in Aircraft Fleet on Adding Smaller Jets 27

Table III.1 – Suggested Equipment Substitution 48

Table III.2 – Equipment Options Potential for Cost Recovery 49

Table IV.1 – Comparison of Average Prices of North American, Japanese and European Cars Sold in Canada, 1978-80 65

Table IV.2 – Ratings of Overall Vehicle Quality, 1979 Passenger North American and Imported Products, by Members of Consumers' Union 67

Table IV.3 – Average Fuel Consumption of North American, Japanese and European Cars in 1980 and 1981 67

Table V.1 – Comparison of Expanded and Conventional Buses 84

Figures

Figure III.1 – Intercity Passenger Rail Vehicles 47

Figure III.2 – Cost Curves for Locomotive-Hauled, RDC and BRC Trains in Consists up to Five Cars 50

Figure III.3 – Seat-Kilometre Costs at 60 per cent Load Factor for BRC, RDC and Locomotive-Hauled Trains 52

Figure V.1 – Comparison of Existing and Lengthened Buses 85

Figure V.2 – Turn Circle Comparison of Existing and Proposed Buses 87

Preface

Canadians view transportation much as they view the weather. They grumble about it, they seldom admit they enjoy its benefits, and they benignly believe that they can do little about it. Professionals in government agencies and the transportation industry, however, know otherwise. They know that much can, and should, be done to change the shape of transportation in Canada.

This report was written to recommend changes that should be made to prepare Canadian transportation for an "energy-conscious" future – that is, a future in which the cost and the availability of suitable energy sources are an ongoing concern. It also recommends ways to improve Canada's industrial development opportunities in the area of transportation.

The recommendations are aimed at those who are charged with the responsibility for determining the "public good" – that is, Members of Parliament and the Legislative Assemblies as well as policy planners within government, the operating companies, the manufacturers of transportation equipment, and their associations.

It should be of value to a broad range of public bodies, including the Canadian Transportation Commission, Department of Industry, Trade and Commerce, National Research Council, the Canadian Motor Coach Association, the Automotive Parts Manufacturing Association, the Motor Vehicle Manufacturing Association, the Air Industries Association, and so on.

The report was also written for interested members of the Canadian public and provides, in nontechnical terms, an interesting overview of our transportation system.

In addition to making specific recommendations, the report was written to stress the following points:

- *in the minds of the public* that although the cost of travel will rapidly increase, there is a chance of reducing that increase by selecting some transportation modes instead of others;
- *in the minds of the manufacturers* that they must use the most modern equipment in the vehicles they build, the most modern methods to design them, and the most modern means to manufacture them, if they wish to survive in the face of foreign competition;

- *in the minds of policy and regulation makers* that a decision to promote one public mode, in the hope of lowering subsidies to that mode, raises the danger of having to transfer the subsidies to the abandoned mode.

Scope of the Report

The scope was restricted to intercity passenger transportation by the three public modes of air, rail and bus and by that most extensive of private modes, the automobile. There is little mention of those transportation modes that carry only a tiny fraction of total passengers or that are insufficiently developed for public use – e.g., ferries, helicopters and dirigibles. Propulsion systems and new capital-intensive networks that cannot possibly be in place before 1990 are given passing mention only. The major use of the rail and road transportation systems – i.e., the movement of freight and commodities – is not covered at all; it deserves another study of its own.

This report delineates the problems of intercity passenger transportation, both current and projected up to 1990. The structure and operational character of the industry, the institutional and regulatory framework, and the capabilities of the manufacturing segment are assessed by mode and compared between modes.

The report aims to be of practical value, so a large number of recommendations have been made. We left out recommendations that would not be applicable before 1990, that were judged to be beyond the capital resources of the country, and that were felt to be unacceptable to the Canadian culture. We deliberately emphasize recommendations that might provide special opportunities for Canada in science and technology, in modal management and in industrial activity. These recommendations generally involve new vehicle designs, new operational methods and innovative manufacturing procedures. They are specifically aimed at

(*a*) reducing total energy consumption,

(*b*) reducing operational deficits and the subsidies now paid by the general taxpayer, and

(*c*) encouraging the appropriate use of computer-aided technology by Canadian transportation manufacturing.

How the Report Came About

In 1977, the Science Council set up a transportation study committee, Opportunities in Canadian Transportation (see p. 103), which guided the research and analysis that is the basis for this report. The committee convened five large conferences, two with invitees whose combined knowledge included all aspects of transportation, and three that addressed specific modal problems. These conferences were supplemented with a number of working and research papers. (For a

complete list, see Appendix 1 on p. 92.) The committee initiated a series of other reports, and members circulated and discussed them. Also, the committee was able to draw on the work of earlier Science Council studies. (See Appendix 2 on p. 95.)

No chairman has been privileged to work with a committee of more knowledgeable individuals than I have been, working with the members of the transportation study committee. I wish to express my sincere gratitude to the hundreds of individuals who participated in our conference series and who responded to the many inquiries and consultants' questionnaires to which they were subjected. To our consultants and to the Council staff go my sincere appreciation. I wish to thank especially Dr. Alan Blair who, as project officer, guided the study in its initial two years, and Sam Gelman who guided the project for a further year and who gave valuable advice and assistance in shaping this final report. Without him and his able research assistants, Patrick Hoey, Alan Taylor and Harry Valentine, this document could not have been started.

J.J. MacDonald
Chairman
Transportation Study Group

Chapter I

Growth to a Multimodal System

How the Transportation System Developed

Transportation is intricately woven into the fabric of Canadian history. Its genesis lies in the will to conquer a vast new land, and its growth lies in the necessity to provision and communicate. It evolved from the military post road and the *coureurs de bois* freighting rivers, to a network of arteries carrying the nation's lifeblood. The rail system alone acted as an umbilical cord for the birth of new provinces in our Confederation. Roads and rail allowed the young, the daring and the hardy to settle our land and to extract its rich natural wealth. The railroad network was virtually complete by the end of the nineteenth century, the highway system by the 1950s, and even the air mode now has an established aerial highway. Except in the northern reaches, our transportation system is one of "maturity."

As Canadians, we expect – and generally enjoy – flexible, convenient and reliable transportation. Too often, we forget that our transportation system must serve a large country with a harsh and changeable climate and a relatively small and dispersed population. Canadians are second only to Americans in their addiction to the automobile; yet, they also have access to a wide range of air, bus and rail services. As a result, transportation is now a major part of our economic life. It is responsible for about 7.5 per cent (1977) of the real domestic product and employs directly 7 per cent of the total work force, divided roughly 2/3 in the operating system and 1/3 in equipment manufacture; and it accounts for about 13 per cent of the average family's budget.

The importance of transportation does not show up in our use of bus and rail: among the nine leading industrial nations, we rank eighth in the number of passenger-kilometres per capita travelled by these two modes.[1] However, in automobile ownership and kilometres travelled per capita Canadians rank second, and in air travel, we rank third. Our proclivity to use the automobile and the airplane reflects the nature of our country, its geography and the abundance of our natural energy resources. As far as costs are concerned, the Transportation Price Index in Canada during the decade and a half prior to 1973 rose more slowly than in the other leading industrial nations, reflecting the introduction of new Canadian equipment and the relative efficiency of the Canadian system. Since 1973, however, transport prices in all countries have accelerated greatly and increases in Canada are now roughly equal to those elsewhere; also, they now exceed the rise in the Consumer Price Index.

The movement of people in the transportation system occurs essentially through four modes: auto, air, rail and bus. (An insignificant number of people travel intercity by water.*) Each of the

* The majority of passengers travelling by ferry on both coasts do so as part of a longer journey undertaken by bus, rail or private automobile.

four modes developed essentially independently from the others, and Canada has committed resources to each in an uneven manner during the last 100 years. The rail mode, once the mainstay of transportation, declined after World War II, only to be reborn in the past decade through resumed subsidies. The auto mode mushroomed when nurtured by extensive networks of quality highways and inexpensive gasoline. The glamorous travel mode after 1950 was air; the unglamorous mode was bus.

Modal coordination and balance has never been attempted. A study of almost 34 000 route-kilometres covering all of the domestic rail service found that buses paralleled rail along 71 per cent of the distance, with highways paralleling a further 14 per cent. Rail was the only available mode over just 15 per cent of the distance. Although such duplication of service may seem redundant and ill advised, it did not grow entirely like "topsy." Legislation and regulation have played a major part in the evolution of each modal system. Their peculiar Canadian interaction requires elaboration (see p. 11), but first let us examine the main characteristics of each of the four modes.

Passenger Characteristics and Modal Attributes

People travel for business, urgent family or personal reasons, or for recreation and pleasure. Some travel is *required* and some is *discretionary*. The former constitutes about 40 per cent of all intercity travel. Required travellers are willing and able to exchange dollars for a perceived time advantage, modal convenience, service frequency and trip flexibility. Cost is generally not a principal consideration of choice of mode for those able to pass it on. Travel *time* thus tends to emerge as the most significant factor. In contrast, discretionary travellers may decide to go or not to go. They can more conveniently choose when to leave and how to travel, and they can cause large seasonal variations in demand. They trade speed and convenience for cost savings. Significantly, the use of energy seldom, if ever, enters into an individual's choice of mode, regardless of whether that individual is a required or discretionary traveller.

Each mode offers its own advantages:

1. The *auto* offers reasonable travel speed, route flexibility (over a network of roads provided and financed by the provinces),* convenience, privacy, perceived low operating-cost and strike-free reliability. Little consideration is given to driver stress, risk or the unavailability of the driver's time for other work.

The automobile emerges as the benchmark intercity mode

* The Trans-Canada Highway was a joint federal-provincial venture.

accommodating more than 80 per cent of passenger-kilometres travelled for distances of 500 or even 800 kilometres on quality highways. The vast majority of both required and discretionary travellers will not readily abandon the auto in favour of the public modes. Studies do show, however, that steeply rising costs and lengthened travel times – e.g., through lowered speed limits – can induce a shift to other modes.

2. *Buses* offer reasonable travel speed, route flexibility (over the same network of roads provided and financed by the provinces), convenience and a relatively low-cost fare.

However, buses are noisy, provide poor ride-quality, lack amenities onboard and generally have substandard terminals. The public image of the present intercity bus is a poor one. The mode has traditionally been favoured by those to whom the direct cost – i.e., the fare charged – is of considerable importance.

3. *Railways* offer reasonable travel speed, convenience (which is often equated with security), and a reasonably low-cost fare (kept low by a large annual federal subsidy program). Its best performance is attained on "corridor" routes, which are a significant but limited proportion of the overall network.

The rail mode also has a number of negative characteristics, including infrequent service, perceived unreliability and generally poor riding comfort.

4. *Air travel* offers high speed, route flexibility (utilizing airports and ground facilities that are federally financed) and convenience. However, it costs substantially more. The mode has no contenders for those wishing to travel quickly distances beyond 900 kilometres. Also, it is the public mode with the highest proportion of required travellers.

How the Costs Compare

Among discretionary travellers, the use of any given mode is related to cost. Table I.1 gives the one-way fares, or their equivalent, between various city pairs for conventional take-off and landing aircraft (CTOL), rail, bus and the automobile. In the case of the automobile, Table I.1 shows "perceived" and total costs for the driver travelling with one passenger. The "perceived" cost includes only the fuel consumed and parking fees; the total cost includes a portion of depreciation, insurance, repairs, oil changes, and so on.

The table shows that a premium is paid for rapid travel by air, and that rail and bus are priced competitively. It is also clear why auto is the dominant intercity mode. Even when used by the driver alone, the perceived auto cost is not much greater than the two other

Table I.1 – One-Way Line Haul Fares, one person, 1981

	CTOL ($)	Rail ($)	Bus ($)	Auto, carrying 2 persons	
				Perceived Cost ($)	Total Cost ($) (Fixed + Variable)
Halifax-Sydney	80	24	21	11	15
Halifax-Moncton	71	18	17	7.5	11
Halifax-Saint John	71	29	25	12	15.5
Montréal-Québec City	72	18	18	6.5	10
Montréal-Ottawa	65	13	13	5	9
Montréal-Toronto	93	32	21	15	19
Toronto-London	67	14	11	5	9
Edmonton-Calgary	73	22	14	8	11
Vancouver-Kelowna	63	—	21	12	15.5
Vancouver-Kamloops	63	18	18	11	14.5

Sources: CTOL: March 1981 fares without tax – Airline schedules and reservations offices. Rail: VIA Timetable for 29 September 1981 to 25 April 1982. Bus: *Russell's Guide*, March 1982 and bus-line ticket offices. Auto: for a 1982 6-cylinder Citation 4-door, from CAA, *Car Costs*, 1982.

ground modes. And if the driver recognizes the total cost of each trip, then the premium paid is still not large compared to the convenience gained.

When a passenger is carried, the automobile becomes the least expensive way to travel, per person, in almost every instance. Steeply rising gasoline prices affect auto travel more than rail or bus. This might, at first glance, be expected to force its cost to surpass the other two, but this doesn't always happen. Rising costs associated with other aspects of the bus and rail – e.g., wages, capital, etc. – make it difficult for these two modes to hold down their fares. These issues are discussed in the chapters that follow.

Subsidies for the Various Modes

The support for each of the various modes, provided by all Canadians through their tax base, is normally called a subsidy, and it is always a subject of considerable controversy. Some subsidies are direct – e.g., those paid to VIA Rail to cover operating deficits – but most are indirect through the provision of facilities and services networks, built either exclusively for passengers or for the transportation of goods and commodities as freight. The allocation of costs is necessary to compute indirect subsidies, but cost allocations are always difficult and subject to interpretation.

Table I.2 – Calculation of Transportation Subsidies, 1978-79 ($ in Millions)*

	Rail†	Road‡	Air†
Expenditure		$4 450	$635
Revenues		2 700	271
Subsidy required	$446	1 750	364

* Indirect subsidies through the support of lower than world petroleum prices are not included in these figures.
† Data on rail and air transport from CTC annual reports.
‡ Road expenditures and auto statistics from provincial ministries of transportation.
Note: All rail and $2 million of air subsidies are for operations – the remainder for capital investment.

One method of computing subsidies is to compare the total expenditures and revenues accorded to the total transportation system. Table I.2 shows the deficits that must be made up. The figures are intended to indicate relative magnitudes only and include the support for many services over and above intercity passenger traffic. It is conventional wisdom that the automobile incurs a relatively low passenger-per-kilometre subsidy (about 0.6¢) and that the large portion of its total cost is absorbed by the driving public. The bus mode is considered by both its operators and several provincial studies to be "paying its own way" for the use of roadways. The direct subsidies to

VIA Rail are highly visible, whereas those for air, in the provision of terminals and services, are less so.

Problems Facing the Transportation System in Canada

Jurisdiction and Regulation

It was tacitly assumed when the transportation system was rapidly expanding that resources for transportation were unlimited. The notion of multiple options was easily promoted, and parallel capabilities were instituted and augmented with minimal constraint. If something was in the general good, then more of it and in a larger size was taken to be even better. If one region had something, then others should have it too; if one mode had it, then so should the others. Alternate routes and modes would alleviate disruptions by the forces of nature or dislocations through strikes.

The expense of providing such a system under Canadian conditions began to be felt by 1965 and was the reason for the National Transportation Act (NTA) in 1967. The intention of the NTA was, first, an economic and efficient transportation system and, second, adequacy. Policy makers and the managers of systems faced conflicting objectives: economics and efficiency might suggest the curtailment or discontinuance of certain high-subsidy or inefficient operations, but the requirement of adequacy might demand their retention. Resolution of this conflict is almost impossible. Also, it is an issue that must be dealt with by the Parliament of Canada, so it is subject to the oscillation of differing political viewpoints.

If these were the only forces affecting the transportation system, then that system could perhaps be more easily shaped and controlled. In fact, there are many other forces and many other players, including the carriers, the provinces, Transport Canada, the Canadian Transport Commission (CTC) and federal Crown corporations such as Air Canada and Canadian National. These groups often work independently and at cross purposes.

Transport Canada, the department responsible for policy, research and advice, and the CTC, responsible primarily for regulation, were meant to play complementary roles. Transport Canada has an air, marine and surface administration (responsible for CN, VIA Rail, the Trans-Canada Highway and ferry services); whereas the CTC has an air, rail and water committee. However, the provinces are responsible for bus traffic, for the enforcement of auto-safety regulations developed by Transport Canada, and for smaller airports. This fragmented regulatory reponsibility complicates policy formulations. To make matters worse, the major legislation – i.e., the NTA plus transportation policy amendments of 1975 and others –

Table I.3 – Current Transportation Policy by Instruments, Modes and Governments

	Economic Regulation	Infrastructure Investment	Crown Corps.	Operating Subsidies
Air	Yes *F**	Yes *F*	Yes *F, P*	Yes *F*
Auto	No	Yes *P, M, F*	No	No
Intercity Bus	Yes *P, (F)*†	Yes *P, M, F*	Yes *F, P*	Yes *P*
Railway	Yes *F*	Some *F, P*	Yes *F, P*	Yes *F*

* *F* denotes federal, *P* denotes provincial, and *M* denotes municipal government in rough order of importance.
† *(F)* refers to provincial exercise of federal jurisdiction over interprovincial highway transport pending the possible introduction of direct federal regulation.
Source: J.M. Munro, "Canada's Need for a New National Transportation Policy," *Proceedings*, 16th Annual Meeting in Joint Session, Canadian Transportation Research Forum, vol. 16, no. 1, 1975, p. 287.

still leaves gaps in policy and does not clarify the complications of overlapping jurisdictions.

Table I.3 summarizes the current situation, showing that jurisdictional problems can arise in three areas: (*a*) between the government and the private sector; (*b*) between any of the three levels of government (federal, provincial and municipal); and (*c*) between the various departments and agencies, including Transport Canada, the Crown corporations and the CTC. Amendments to the Canadian Transportation Act, tabled in Parliament in 1977 and reintroduced subsequently, were intended to clear up many of the policy and regulatory problems. But the bills died on the Order Paper.

The net result of the policy gaps has been a lack of direction for the carriers during the 1970s. Table I.3 also shows that in the important areas of investment in the infrastructure, all of the transportation modes have been assisted.

The Problem of Energy

It is not possible to predict with any accuracy how great the "energy crisis" of the 1980s will be. There may not even be a crisis. Alternatively, energy may be in relatively abundant supply, but be extremely expensive. Or it may be scarce and, in some cases, not available at any price.

However, one thing is certain – the 1980s will be a decade of energy awareness. Transportation is a large and growing consumer of energy. In 1976, transportation in Canada used about 26 per cent of the total secondary energy*; in 1980, it used about 30 per cent of the total secondary energy.

* The energy actually used by customers in its final form.

Table I.4 – Approximate Direct Energy Consumption by Mode

Mode*	kJ/Pass.-kilometre†
Air – CTOL	3 606
– STOL	3 147
Auto	2 295
Rail	918
Bus	656

* Load factors assumed: auto – 40 per cent; all others – 60 per cent.
† 1 kJ = 0.9478 Btu.

Table I.4 shows the direct energy use of the different passenger transportation modes.*

Energy efficiency depends on load factors. A large, almost empty bus burns more fuel per passenger than does a less energy-efficient automobile carrying only the driver – but much less when the bus is reasonably filled. All recent studies confirm that, given the present and foreseeable load factors, the bus is the most energy-efficient mode, and air is the least efficient.

The energy values cited above include all sources of secondary energy. Intercity travel depends almost totally on petroleum-derived fuels, and, looking at those fuels only, intercity travel consumes about 50 per cent of the total used in Canada today. The automobile is by far the largest consumer.

Thus, to save on energy resources, particularly petroleum-based ones, it is necessary to shift passenger travel from air and auto to rail and bus. The intercity bus, or a reasonably loaded passenger train, is somewhere between 3 and 15 times as efficient, in terms of energy usage, as is the typical passenger car over the same distance. The wide variation depends upon the number of passengers the auto carries. Highest fuel efficiency is achieved only with four or five people in the car – a very uncommon sight on intercity highways.

The improvement of load factors on all public modes will be in the interest of energy economy.

The Search for New Fuels

There is a worldwide search for new fuels that can be substituted for oil. These include alcohol or gasohol, synfuels from natural gas and coal, compressed gas and liquid hydrogen. Natural gas, currently in excess supply in British Columbia, will undoubtedly be used to some degree as a substitute for gasoline. Propane is already seen as a

* Comparisons of direct energy consumption per passenger by mode with those that also include "indirect" energy values, i.e., that required to produce the fuel, that used in the manufacturing and maintenance and operation of the infrastructure, lead to slightly different values but do not change significantly the relative relationships between the energy efficiency by mode. Detailed comparisons are given in Working Paper 3 by A. Kahn. (See Appendix 1, p. 92.)

practical substitute in taxis, delivery vans and utility trucks where central fueling facilities are available.

The substitution of electricity for oil is another option. Although electric-powered automobiles are still in the R&D stage, the electrification of rail lines involves, to a substantial degree, known technology. Thus, the availability of hydroelectricity in a number of provinces* would seem to make the electrification of rail lines a possibility in some areas. There are immense capital costs involved, and only hydroelectricity gives a favourable net energy equation in some regions.† Any additional electricity required, if generated from nuclear or oil-fired generating stations, would not diminish our total energy consumption.

To summarize the fuel future: to the extent that we decide to use "nonmobile" fuels (such as natural gas or coal) for stationary heating needs, we make a larger proportion of hydrocarbons available for motor gasoline, diesel and jet fuels; new cracking processes and flexibility in current processes can increase the availability of gasoline and diesel fuels from a given volume of crude; changes to higher vehicle-fuel-consumption efficiencies will provide a significant volume increase in intercity passenger transportation at the same energy consumption level.

The availability of gasoline, diesel and jet fuel does not immediately threaten a drastic curtailment in intercity passenger travel. A recent report indicates that, in 1980, Canadians made slightly fewer trips (2.6 per cent decline)[2] than they did in 1979. Such travel suppression is due to higher fuel costs, inflation and high interest rates, rather than fuel shortages.

Other Problems We Face

The energy crisis of the 1970s – specifically, the oil shortage in 1974 and the rapid rise in prices in 1979 – triggered a series of other upheavals.

One is the revolution taking place in the auto industry. Vehicle design and manufacturing is still undergoing an enormous upheaval, having to produce not only environmentally acceptable cars, but also ones that are smaller and more fuel efficient. Furthermore, the production milieu that was dominantly based in North America has shifted to include many distant lands and to take advantage of global economies of scale.

The second problem is inflation, and its recently attendant devil, the cost of capital. They have raised the cost of debt service and have restrained the amount of capital available. Increasing operating

* More than 80 per cent of electric power is obtained from hydro sources in Newfoundland, Québec, Manitoba, BC, the Yukon and the Northwest Territories.

† Electricity, however generated, enters a distribution grid system and cannot be differentially priced to the user according to source.

costs squeeze profit margins, thereby inhibiting the refurbishing of equipment and innovation. Not unexpectedly, the private sector has adopted a watch-and-wait stance in all modes other than the auto mode.

The third major upheaval comes from the deregulation of the air mode in the United States, which in turn has led to limited deregulation in Canada. The new competition among carriers has mandated better efficiency in management and in operation, because energy supplies have been both scarce and expensive.

Fourthly, there has been the continuing deterioration of the most mature of Canadian transportation systems – the rail mode.

Inflation, deregulation and mature-system aging do not stem directly from the energy crisis of the 1970s, but certainly they are all exacerbated by it. An energy-conscious future is certain to be transportation's destiny.

The Travel Alternative: Network of Newest Electronics

Improved telecommunications technology could sharply reduce the need for travel. Admittedly it cannot replace the family reunion or vacation, but without doubt it can be an effective substitute for some forms of travel. In particular, because vast quantities of data, opinion and discussion can be transmitted, it can serve as a substitute for some professional and business travel.

However, telecommunications still suffers from inadequacies in technology. Face-to-face communication is not yet possible, although multiscreen and life-size imagery from projection television should be available by the mid-1980s, and digitization and multiplexing of signals and direct broadcast satellites (DBS) may be available by 1990.* At present, little benefit is gained by such speculation; the impact of this new technology is uncertain. This report assumes that telecommunications will not have a significant impact upon travel until the early 1990s.

* Bell Labs has developed a new band width compression technique that will permit the transmission of good quality live TV pictures over ordinary telephone wires. J. Bell-Walker, *The Delta Report*, Transport Canada, December 1981, p. 4.

Chapter II

The Air Mode

The Flight from Yesterday to Today

The practicality of flight was firmly established during the First World War. Commercial aviation began shortly thereafter. Adventuresome entrepreneurs set up small airlines in Canada to link the major urban centres and to fly people and supplies to remote sites in the North and elsewhere. At the time, federal government support was limited to airmail contracts and some assistance in the building of municipal airports. The Air Board Act of 1919 essentially covered only questions of safety.

Later on, the railways were encouraged to set up a national airline – because they were the dominant carriers of passengers – but they were unwilling to do so. In 1937, the Department of Transport therefore established a Crown corporation, called Trans-Canada Airlines: its mandate was to offer a commercial, nationwide scheduled service that was in the public interest; beyond that, its role was left largely undefined.

Canadian Pacific Air had begun operations four years earlier, in 1933, having bought into Canadian Airways. It evolved into its present form in 1942 through the amalgamation of 10 smaller airline systems. Its operations experience further developed during the Second World War, when it ferried bombers across the Atlantic. Thus, by the end of that war, there were two national airlines in Canada.

In the next few years, largely to protect the interests of those national airlines, government policy was extended to the licensing of new routes and to the responsibility for airports and other infrastructure. Its licensing authority (under the Minister of Transport) was then further expanded allowing a few smaller airlines to become established as north/south regional carriers. The smaller airlines provided little serious competition to the two national carriers. It wasn't until 1966 that regional air-carrier policy allowed limited competition. Unfortunately, service to the public did not improve because, by that time, longer jet aircraft were being introduced, and those cities too small to be serviced by jets were dropped. These cities were not properly serviced until a new class of carrier stepped in to fill the gaps.

Today, there are three levels of carriers operating scheduled flights. Level One consists of the two national carriers, Air Canada and CP Air. Level Two consists of the four regional carriers, Eastern Provincial Airways, Québec Air, Nordair and Pacific Western Airlines. Level Three consists of 69 local carriers and include Time Air in western Canada and Great Lakes Airlines in central Canada. In addition, there are charter carriers – e.g., Wardair – that do not fly scheduled routes.

Controlled competition best expresses Canada's air transportation policy. It permits service, on mainline and medium-density routes, by both the national and the regional carriers. Nordair, for example, flies Montréal-Toronto and Eastern Provincial flies Halifax-Toronto, both in competition with Air Canada and CP Air. However, mainline carriers are not always permitted to compete on regional routes – e.g., Edmonton-Calgary.

How the Airlines Compare

Air Canada carried two-thirds of Level One and Level Two revenue passengers in 1979, and it continues to dominate the industry. However, its share has declined from three-quarters of the total since the regional carriers were established after 1966. It serves 31 domestic and 27 foreign points. CP Air, serving 16 domestic and 17 foreign points, has approximately one-quarter of the revenue passengers. Pacific Western Airlines, the largest regional carrier, has 4 per cent of the revenue passengers. As a rule, service between cities is provided by one carrier only. Of the 168 intercity routes with more than 10 000 passenger trips in 1977, 55 per cent were licensed for one carrier only, and only 8 per cent were served by more than two carriers.*

Distinctions between national and regional carriers extend beyond size and the area of flight jurisdiction. Air Canada and CP Air concentrate almost totally on scheduled passenger service;† whereas the regionals derive 5-15 per cent of their revenue from charter operations. The national carriers also fly their passengers a much longer average distance.‡ The regional airlines as a group operate within a network of shorter stages, between smaller cities, and consequently they fly fewer flights on a daily basis, with lower average load factors. This means they have higher net costs, generally higher fares and smaller average aircraft than their national counterparts. The national carriers have tended to be the price-setting leaders by being the first to file for rate increases and to announce special discount fare promotions.§

The 69 Third Level carriers are much smaller operations but, in 1979, they reported a total of almost $68 million of unit toll revenue and $365 million of charter revenue. All of them gross at least $300 000 per year. These carriers enjoy fervent local and provincial

---

* This is remarkably similar to the US experience where in a deregulated environment in 1978-79 only 12 per cent of the routes had more than two competitors. On such routes no single carrier had more than 70 per cent of the traffic in either Canada or the US.
† Unit toll revenue passenger service.
‡ It was 1067 kilometres in 1978 compared to 303 kilometres for the regional carriers.
§ Eastern Provincial Airways in 1981 was the first to challenge this position.

support and attention; yet they operate without a clearly established Canadian Third Level air-carrier policy.

Regardless of size, Canadian airlines are very reliable. The Level One/Level Two carriers operated 97 per cent of their flights as scheduled in 1978, and almost 80 per cent of all flights arrived within 15 minutes of scheduled time. Nonstop service and interregional same-plane service is on a level comparable to that in the United States. Canadian airlines' safety and accident records are comparable to the leading foreign carriers.[1]

The use of the most modern aircraft available has always been the norm: for example, Air Canada was flying an all-jet fleet by 1967. Throughout the 1970s there was a consistent drive to update fleets with higher capacity aircraft. The lower operating costs, on a seat-kilometre basis, encouraged lower airfares and helped swell the growing volume of traffic. During 1973-78, Canada's top 25 airports reported 5 per cent more flight departures and 17 per cent more deplaning passengers.

Canadian air travellers today enjoy reliable, relatively comfortable and safe flights. Also, they may choose from an ever-increasing variety of fare packages. Few domestic first-class fares are still available, and "deep discount" fares have changed the reasons that many people fly. Business is still the dominating reason for a domestic trip, but it is now responsible for less than 66 per cent of the market – a decline from 72 per cent in 1970. A 1978 survey shows that more than half of the air travellers had incomes greater than $20 000 per year; yet only about one-fifth of the Canadian adult population earned this much. Thus, the air mode caters to a well-defined and exclusive market: one that depends on convenience and speed and one that will be reluctant to transfer to ground modes without deluxe comfort and excellent service.

Coping with the Oil Crisis

In the 25 years between the introduction of the jet engine into commercial aviation and the dawning of the energy crisis, demand for air transportation grew more rapidly than the demand for all other modes, at an average annual rate of 18 per cent in terms of passenger-kilometres. In terms of real domestic product (RDP), growth averaged more than 14 per cent per year. And in terms of its share of total transportation services, it leaped from 2 per cent to 16 per cent. At the same time, the growth of capital expenditures averaged 12 per cent per year.

These increases halted in 1974 because of the shortage and rapidly increasing cost of aviation fuel. These problems were compounded by the beginning of high inflation, the onset of a world

recession, budget restrictions in both the private and the public sectors, and the increasing cost of capital.

In spite of these problems, an analysis of the financial performance of Canadian airlines during 1974-80 shows some startling and unexpectedly positive results. Table II.1 gives aggregate figures, which show that operating revenues rose even more rapidly than operating costs, while traffic increased by more than one-third. This is a good performance at any time, and an excellent one for the time in question. Even more remarkable is the fact that this good performance was achieved with little direct government subsidy. Only $1.6 million, a relatively unimportant share of the carriers' 1980 income, was provided by way of direct subsidy. Indirect subsidization through airport construction and maintenance of the infrastructure has always existed.

Table II.1 – Air Canada, CP Air and Regional Carrier Financial Data

	1975	1979	Increase (%)
Total Operating Costs ($ million)	1 494	2 420	62
Total Operating Revenue ($ million)	1 541	2 568	67
Revenue Passenger-Kilometres	28 363	36 585	36
Operating Ratio	0.97	0.94	
Rev. Passenger-Kilometre	5.4¢	6.6¢	

Aggregate figures are often misleading. They fail to show the ever-increasing proportion of income arising from nonflight and nonoperational activities, which now contribute 39 per cent of before-tax income. Their share was just 15 per cent in 1975. Also, they fail to show the fluctuations in profitability and the fact that some carriers in some years operated at a loss. What they do show, though, is the high ratio of operating expenditures to operating revenues and hence the industry-wide low profitability. And they show that, at 8.7 per cent, the industry's return on investment does not compare favourably with the 9.5 per cent return for the entire transportation industry, or the 11.5 per cent return for all Canadian industry.

The major component of total costs is labour, at 36 per cent, but this component was relatively constant during the 1970s (regional airlines are now beginning to pay a slightly higher proportion). Material costs account for 30 per cent, but they have been declining slowly. In contrast, the cost of aviation fuel has increased at a startling rate. Traditionally less than 10 per cent of operating expenses, this cost reached about 11 per cent in 1970, but it is now 21 per cent and is forecast to be at least 35 per cent in 1985 and more than 40 per cent by 1990. The price of fuel for Air Canada went up by 500 per cent during 1972-79.

In the face of these increases, the airlines have maintained financial viability and have even increased revenue; so clearly they have managed their affairs well. What is now in doubt is whether they can keep this performance up.

Applying the Remedies of the Past

Throughout its history, aviation has managed to increase its revenue faster than the rate of growth in the consumer price index through increased productivity obtained by the continual introduction of new, higher technology airplanes. This constant stream of new aircraft types was responsible for the growth of air travel from the beginning. However, no new aircraft were introduced in the 1970s. The B747, which is the last major airplane to reduce seat/kilometre costs, first flew as long ago as 1962. Recent extensive efforts have instead been aimed more at reducing fuel consumption per passenger-kilometre.

These efforts have involved the removal of first-class seating and other ways of increasing seat densities, the assurance of higher load factors through discount-fare arrangements, the retirement of older fuel-inefficient aircraft, the conversion and upgrading of engines, and the improvement of ground "taxi-ing" procedures and routing and approach paths. The net weight of the aircraft and the amount of reserve fuel carried have also been reduced. Optimal cruising speeds and altitudes have been computed and followed by some of the major carriers. And in some cases, paint has been scraped from the fuselage to reduce drag.

All of this has evidently been productive, but how far can the efforts continue? The newer aircraft on the horizon will not offer the same proportion of improvement over their predecessors as did the last generation. The new B757 and B767 will offer 20-30 per cent better fuel economy, but they are suitable only on certain routes and will not raise the fleet average by more than 10-15 per cent during the next decade. Air Canada is replacing the engines of its DC-8s with the General Electric SNECMA CFM 56, a high-bypass-ratio engine that is fuel efficient, and it is modifying its Pratt and Whitney engines on its Boeing 727 and 737 aircraft. This five-year modification program is expected to save the airline $500 million in fuel costs over five years. But neither the new generation of aircraft nor the modification program is likely to solve the problems of rising energy costs.

What strategies then remain? The regional carriers have already dropped uneconomic charters, and they have initiated a route rationalization that is designed to eliminate less profitable routes and to reduce the number of stops. These measures have effectively offset escalating costs so far: only a small proportion of the increases have been passed directly on to the consumer. However, such initiatives have been almost fully exploited. Only one strategy remains:

the large cost increase for aircraft fuel, which Canada faces in the next decade, will have to be passed directly to the travelling public.* There is therefore a danger that only those on business or the wealthy will be able to fly.

The enemy then is the continuing crisis in fuel and, to a lesser degree, rising operating costs in general. Inevitably, we will see much higher fares, despite route rationalization, more direct flights, and very high load factors. This presents a serious problem for Canada, because air travel in this country is not simply a means of conveyance; it has a special importance for our cultural and economic life. The Canadian climate, which makes winter auto and bus travel hazardous and difficult, plus the long distances between major cities make convenient air travel essential.

What possible solutions are there to future service cutbacks and the higher fares? Obviously, there could be a return to lighter-than-air craft, the dirigible, or to the fuel-efficient piston turbo-prop airplanes, but both these solutions pose other inconveniences that are not likely to be overcome or accepted. Exotic fuels or the hydrogen-fuel economy are not possible before the year 2000. What is needed, perhaps, is greater Canadian expertise in a specific segment of the aircraft industry and the use of that expertise to find other solutions. This possibility is investigated in the sections that follow, but first we will look at other ways of improving the air mode.

Air Service and Transportation Policy

Canadians, as has been shown, are well serviced by their airlines. The overall system functions well. However, service can deteriorate rapidly if the capacity of a few major airports is exceeded. Today's route structures require extensive use of Malton in Toronto, Dorval in Montréal and the International Airport in Vancouver. Capacity constraints at these centres will induce inefficiencies that not only cause passenger inconvenience, but also waste precious petroleum resources. The capital investment to provide new key airports or to extend the current ones is very large.†

Optimization of airport capacity must first involve noncapital or low capital alternatives to major new construction. Changes in air

---

* Very simple calculations show the magnitude of the effect of rising fuel prices. At 4.4¢ per litre in 1970 a Boeing 737 required approximately $153 of fuel to fly for one hour. At today's prices the equivalent cost is $690. If the price reaches 57.2¢ per litre by 1985 the fuel cost per hour will be almost $2000. The effect on the paying passenger follows the price of the ticket; at 4.4¢ per litre, using an average load factor of 60 per cent, each ticket contributed $2.18 to the cost of one hour's fuel; today, it is $9.59; and by 1985, it could be $27.35. It is these costs that will have to be passed directly on to the travelling public.

† Mirabel provides some relief to Dorval, but lacks convenient access from Dorval and the surrounding area.

transportation routes and the transfer of noncommercial aviation to smaller airports in the vicinity are two available options. A third option common to all major airports is the use of more direct flights between cities, bypassing the busy airports at Montréal, Toronto and Vancouver. Today, there are few nonstop flights into and out of Victoria, Halifax, Regina and Ottawa; for example, nonstop service between the prairie communities and Halifax (the major air mode gateway to the Atlantic provinces) is limited to Halifax-Winnipeg. When passengers have to change aircraft at the intermediate stops, the level of service drops. Also, same-day-return trips become difficult, if not impossible. There are far too many examples of this kind of inconvenience in the Canadian route system today. Many of the aircraft changes and associated delays could be eliminated by nonstop flights. This bypassing of busy airports by direct flights between other centres would be equivalent to increasing capacity at major airports and it would provide improved passenger convenience.

The introduction of more direct flights would require modifications in the licensing regulations. The changes would have to include an improved and possibly expanded service by the mainline carriers, the strengthening of the regional carriers' role on selected segments of mainline routes, permission for regional carriers to serve transborder routes, and a larger role for local carriers serving small communities. These are major items of transportation policy, and if adopted, would cause the boundaries currently distinguishing routes served by trunk and regional carriers to become blurred.

Transport Canada's policy is now a compromise between government intervention through regulation and reliance on market forces. Deregulation is now prominent in the United States and has sometimes been promoted as beneficial for Canadians. However, in spite of an initial growth in traffic, higher utilization of equipment, and the gains in efficiency that the American policy generated, deregulation is not considered appropriate for Canada. Canada has a national carrier that is a Crown corporation, and it would be difficult for that carrier to be integrated into a completely deregulated competitive market, and to have it serve the national public interest. The Canadian population is too small and dispersed; it cannot support a multitiered structure of carriers as can the United States population. Also, the United States has tough antitrust legislation that acts as an alternative to regulation. Such legislation is not in place in Canada.

A thorough discussion with the air industry and carriers indicates that, in their view, any change in Transport Canada policy must incorporate the following:

1. A national, integrated system that views all levels of carriers as essential components.
2. A strengthening of the current trend towards greater competition, but without full-scale deregulation.

3. An articulated policy for the charter carriers that would cover their terms of entry in the market, split-chartering* and the moving of cargo on passenger charters.

4. A realization that the interests of the nondiscretionary (obliged and business) traveller must not be overlooked.

Transportation policy also covers the ground side of the operation. The Canadian Air Transportation Administration (CATA) owns and operates 90 airports, and it controls another 79 that are run for Transport Canada by municipalities or other agencies. Planned expenditures in the 1979-80 budget for CATA amounted to $726 million as against expected revenues of $477 million.

This highly centralized airport-management system was the subject of a study by a Task Force on Airport Management, which recommended adoption of a different concept: one similar to the US Airport Commission. Overhead costs in 1980 would have dropped an estimated $40 million if management had been transferred from federal government control to semiautonomous local airport authorities. Federal responsibility for safety and air traffic control must remain, but more flexibility in standards of design and operation of small airports, under the control of local authorities, would reduce the subsidies required.

Small community airports, and the airlines linking them, have expanded rapidly in the past decade. Six hundred and forty-two communities now receive some form of (scheduled) air service from more than 70 local carriers. Often, such service is the only link between isolated communities and larger population centres. Substantial improvements to the small airports have been carried out by the federal Transport Ministry, and in some locations both the airports and the airlines have been supported and upgraded by the provincial government. The demand for navigational aids has grown. For many small communities, particularly those in outlying regions, the desirability of instrument-landing systems (ILS) for safety and service is unquestioned.

Based on the above discussion, Council recommends that the Canadian Transport Commission and Transport Canada should continue to transfer management control to semiautonomous local airport authorities, and also these bodies should continue to facilitate the installation of instrument-landing systems in the smaller centres.

In the interests of both safety and fuel savings, Council recommends that the Canadian Air Transport Administration should investigate the feasibility of the mandatory use by Canadian airlines of electronic inflight and onground control systems and devices, in order to optimize flight routes, altitudes and approaches.

* Split-chartering should allow shippers with partial loads to take advantage of a full-plane-load rate by moving their goods at the same time and on the same plane.

Aircraft of the Future

Increased airline efficiencies historically were achieved by the introduction of new technology and larger aircraft. Air Canada, CP Air, Western Pacific Airlines and Wardair have each ordered a new generation of medium-capacity jet aircraft for their high-density routes. The most recent filled order is Wardair's purchase of six European Airbus A310s. Other carriers have taken options on the Boeing 767, which is another fuel-efficient jet aircraft.

The trend in the past to ever-larger aircraft was based upon the fact that these aircraft gave a lower cost per seat-kilometre. Small airplanes, conventional wisdom said, cost more to operate on a per-seat-kilometre basis, burned more fuel, caused more air-terminal delays for a given volume of traffic, and cost more per seat-kilometre to purchase. However, a fleet consisting only of larger aircraft cannot afford to operate on routes between cities where the passenger volume is too small to provide adequate load levels. Also, if we are to have more direct flights, as this study has suggested, then the airlines are again going to need smaller aircraft. Fortunately, these two apparently divergent trends – towards larger and smaller aircraft – are not irreconcilable.

An extensive computer simulation, matching aircraft size to route loadings, has shown that the introduction of fuel-efficient small aircraft* to a conventional jet fleet can produce overall economies in the air-route system. Direct flights become more feasible, and increased frequency more economical. Also, fuel-consumption comparisons show little difference between a fleet with small jets and a fleet with conventional jets. The explanation for this appears to lie in the longer average stage lengths and the higher average load factors, which result from the smaller average aircraft size. As previously mentioned, the total network efficiency rises as ground costs involved in handling passengers and airplanes at intermediate points are reduced. As a result, an increase in the number of direct flights is beneficial. Also, with an increase in the number of direct flights, airport capacity is effectively increased. There is therefore a strong case to be made for the use of smaller jet aircraft, which have a long range and are fuel efficient. Table II.2 summarizes the results of a study of adding smaller aircraft of 50- and 25-seat capacity to the current conventional fleet, assuming 100, 200, 300 and 400 are the number of seats in the conventional fleet of a Canadian carrier.

No such long-range, fuel-efficient, small jet aircraft exists. However, in recent years, the short take-off and landing (STOL) aircraft have been introduced for short-haul intercity routes. Canada is well represented in this market with the Twin Otter, the Dash-7 and the planned development of the Dash-8. These 19-, 50- and

* Aircraft size in the simulation varied from 25 to 60 seats.

Table II.2 – Effect of Changes in Aircraft Fleet on Adding Smaller Jets

	Base	Alternate 1	Alternate 2
	400, 300 200, 100	400, 300, 200, 100, + 50	400, 300, 200, 100, + 25
Nonstop legs	87	99	118
Roundtrip per average day	277	328	440
Average seat stage length (km)	1 078	1 131	1 155
Installed seats	13 290	12 845	12 628
Average size of aircraft (seats)	148	117	84
Achieved load factor (%)	63.4	64.0	64.2
Annual block fuel (mil. litres)	1 433.3	1 411.5	1 421.1

Source: Adapted from Figure 21 of a paper by C.H. Glenn to the Air Industries Association Conference, Toronto, April 1981.

32-seat planes have a relatively short, 560-kilometre economic cruising range, and a low speed of 400 kilometres per hour. They have turbo-prop engines, low wing loadings and are fuel efficient. The combination of good mechanical flaps and the low wing loading allows them to make effective use of stub runways and to fly tight circuit patterns at low speed in the vicinity of STOL airports. These aircraft fulfill a significant role on short routes including commuter, shuttle and remote community services.

Developing the STOL

As indicated, STOL aircraft do not have sufficient range or speed to meet intermediate and long-range direct flight requirements; they are not jets. But if the STOL features were married with a fuel-efficient jet engine, then this would be a major step towards better network utilization and efficiency and overall fuel economy. It would provide quiet, short-field capability thus reducing main runway traffic and effectively increasing capacity at major airports.

A successful, small STOL jet aircraft requires a number of technical capabilities. It must have a higher cruising speed and range, with wing loadings comparable to current short-range jets. It will need the short-field performance of a turbo-prop aircraft (Dash-7), and the same efficient performance when flying at low speeds in the terminal area.

Research in Canada on augmenter-wing-powered lift designs* provides a strong technological base for R&D. De Havilland Aircraft of Canada has the capability of further research on the application of multifoil elements to very thick wings, having a high aspect ratio with low structural weight. The "fat" multifoil wing not only enhances the augmentation design, but it is also the key to longer range and speed. Wing thickness provides fuel economy, thus permitting much longer, possibly transcontinental, direct flights. A true jet STOL aircraft can thus operate nationwide from shorter runways (760 metres versus 1130-1370 metres for conventional aircraft), thus having the capability of serving many more cities.† Conversely, the same aircraft could operate in the customary STOL mode on short hauls between major city centres. Because of its added fuel capacity, refueling requirements would be reduced and turnaround time shortened. Three one-way trips between Toronto and Montréal without additional fueling would be possible; this would permit a larger number of daily flights per aircraft. A larger, 100-seat version of the jet STOL aircraft (a possible replacement for the DC-9) may be equally acceptable in a network of direct-flight routes. Investigation by De Havilland Aircraft of Canada is now underway for such a larger version, to be used for military purposes. The high development costs of any new aircraft design, plus the long time involved, make any such venture risky. A military requirement is an advantage because it often ensures that development programs continue; civilian designs can be considered and assessed during the military prototype stage.

An essential element in a STOL airplane of any size is an efficient jet engine. Multistream (three-stream) engines are necessary for augmenter wing design. These engines must also have a high bypass ratio for low specific fuel consumption, low exhaust velocity for low noise, a variable pitch fan for glide-path control (making it really a shrouded propeller), a geared fan for low blade tip speeds and low initial and life-cycle costs. The Rolls-Royce RB419 turbo-fan engine is one example now under development. Future research is necessary on multifoil wings, on the thrust augmentation principle and on the bypass-stream engines. Research on engine-noise suppression will also be important, to ensure that future noise-level regulations are met. Expertise for such development already exists within the Canadian aerospace industry. "Flight testing" of the thick wing is perhaps the first step in this development.

---

* The augmenter wing provides thrust augmentation by deflecting 40 per cent of total engine thrust over the wing when the plane is landing or taking off. This provides a powerful lifting force enabling the aircraft to land and take off at much lower speeds than conventional aircraft.

† Although most airports in Canadian cities have runways of sufficient length for non-STOL aircraft, this is not true in other countries.

In conclusion, Canada has undisputed world-class expertise in STOL aircraft. If this expertise were coupled with a jet capability, Canada would be able to offer a long-range jet operable at almost any airport in the world. This would give us access to a global market for a domestically produced vehicle.

Council, therefore, recommends that the federal government, through the Department of Industry, Trade and Commerce and Transport Canada, should carry out a comprehensive global market analysis of the potential applications of 50-100-seat jet STOL aircraft for both passenger and light freight service.

Council also recommends that, if the market analysis is positive, federal R&D funds should be made available through the Department of Industry, Trade and Commerce to refine the concept of STOL aircraft, i.e., multifoil wings, the thrust-augmentation principle and the development of low-noise multistream engines. Such funds should be directed to the Canadian aircraft companies that are world leaders in these areas and to the National Research Council.

Private Aviation

The vast majority of popular light aircraft flown today, whether single or twin engined, originally flew more than 25 years ago. They have undergone little technological modernization; some experts deplore their air worthiness, and even claim that they are inherently unsafe. Certainly, they are unsafe compared to the designs that could be developed with the technologies of the 1980s.

The North American market for light aircraft is very large, and it would appear that an opportunity exists for Canada to enter this market with a new, efficient and safe design. The more conventional designs (e.g., Lear Futura) and the twin-boom pusher propeller and the mid-engine mid-propeller types all suggest light planes that could rival the current popular models. Aircraft based on these designs could capture a significant share of both the North American and the global markets. However, the capital that would be required to design and build them in Canada is very large indeed. The venture would require totally new manufacturing technology, new aircraft plants and a supply of scarce technically skilled labour. Of necessity, it would also require a collaborative arrangement with an established foreign aircraft firm.

Any new technological innovation in the light aircraft industry faces long development times and an extended cost recovery period. The competitive risks, the uncertainty of fuel supply, the certainty of high fuel prices, and periods of economic recession during development, all dampen the prospects. This report concludes that the risks will outweigh the opportunities during this decade.

Canadian Aerospace Industry

The air transportation industry, while relatively young, is a successful and substantial citizen of the Canadian corporate community. Some 35 companies, located coast to coast, generated sales of about $2.2 billion in 1980. The export market accounted for 80 per cent of this amount. Canadian expertise lies in the manufacture of engines, air-frames, fuselages, wings, environmental controls, and electronic and other subsystems for the military as well as commercial and general aviation. Our aerospace companies have a long history of successes and many "firsts" in this complex market. They have taken the lead in the design and development of satellites, surveillance systems, flight simulators, STOL aircraft and prestigious executive jets. Three or four of the companies are world leaders.

As indicated, Canadian aerospace exports have been impressive and favourable; many people therefore conclude that our productivity must be globally competitive. However, there is no field of development that moves at a more rapid pace. It is not an area in which the tortoise wins the race. To assess the ability of our aerospace companies to keep up with their competitors and to grow as major designers, producers and exporters of aerospace products, a cross section of Canadian aerospace companies was examined.[2] The analysis focussed on three key issues: *i*) the extent and rate of introduction of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology; *ii*) the understanding and ability to handle composite materials; and *iii*) the attitude towards, and the ability to do, research and development.

CAD/CAM Technology

Aerospace is an advanced, technologically governed industry that demands access to the very latest techniques. Product quality is undeniably high. The industry employs a lot of automated equipment, but not all aspects of automation are as advanced as they will need to be. Numerically controlled (NC) machines, linked to computers are used exclusively; the cutting tools are controlled automatically and have two-to-five degrees of liberty. This control flexibility is needed to machine the nonlinear shapes common in aerospace structures. Advanced NC techniques yielding three- to sevenfold productivity increases have made conventional machining noncompetitive. The more than 2000 NC machine tools used today divide roughly into 50 per cent lathes, 35 per cent milling machines and 15 per cent others (torches, punches, grinders, riveters, inspection machines, robots, and so on). Almost all NC equipment is imported since Canadian machine-tool builders have found it difficult to compete in the international market, despite a 15 per cent duty protection.

One area that is lagging behind is sheet-metal fabrication, which has not been modernized at the same rate as machining. This area

represents one of the highest labour-content functions in air-frame manufacture, from tooling design and manufacture through detailed fabrication, subassembly and assembly operations. With few exceptions, sheet-metal fabrication in Canada has been unchanged for several decades. Most of the operations are manually controlled, although foreign aerospace companies have been automating for several years.

The major aerospace firms develop their own computer software, using systems analysts and programmers. The smaller firms adapt existing software on upper range minicomputers, but many still employ manual systems. All NC equipment is programmed, generally using an automatically programmed tools (APT) language. Designers and engineers use it to represent mathematically, in a suitable computer base, geometric shapes for required products. Computer graphics and programming systems are now available to apply these programs more efficiently. The graphic systems give productivity improvements of two- to sixfold over any manual system, with improved quality and fewer errors.

The evaluation and selection of any graphic or programming system requires extensive investigation, analysis and comparative testing. There are many computers, peripherals and software packages from which to choose, and to the small user this presents a difficult task. Canadian aerospace companies can benefit from the work, funded by the US Air Force,[3] on automation through the improved hardware and software packages that were developed, or they can benefit from joining the nonprofit organization, Computer-Aided Manufacturing-International (CAM-I). CAM-I has a worldwide industrial membership but is without a Canadian member. Active participation in such organizations is essential if Canadian companies are to keep up with rapid changes in computer-aided technology.

Council recommends that domestic manufacturers become more familiar with the implications of CAD/CAM technology.*

Composite Materials

Composite materials are rapidly being introduced in the aircraft manufacturing industry. The principal reason is weight reduction: constructions consisting of composite materials have less than one-half the weight of conventional aluminum constructions. Secondly, they reduce aerodynamic drag, because external surfaces are smoother and have fewer fasteners. Thirdly, production costs are lower, because fewer tools and parts are needed in manufacturing.

---

* This recommendation is of particular importance to the aerospace industry. However, it applies to other aspects of transportation, too – i.e., bus and rail equipment manufacturing.

Composites, which are really fibre-reinforced plastics (FRP), incorporate a variety of fine fibres or filaments into appropriate matrices to achieve almost tailormade properties for the overall material. They have low density (lightness), high specific strength, high specific stiffness and dimensional stability under a wide range of thermal conditions. They can be made mechanically and anisotropically (i.e., having superior properties in selected directions) through the control of fibre and matrix combination and fabrication processing. They do not corrode; they have a good fatigue life; they can be made tough and nonabradable; and they can be good conductors of electricity.

Reinforced concrete may be considered as an early composite material, with fibreglass a more common recent example. Modern fibres include various glasses, graphites and arimid (Kevlar). The matrix material is often epoxy. The newest fibres of boron, alumina and silicon carbide are very expensive, except for special uses.

In the aircraft industry, secondary structural composites now include nosecones, tailcones, body floor panels, interior compartments, wing panels, doors, wing-to-fuselage fairings, air foils, leading edges, and so on. The gradual transition from purely secondary structures to the primary structure is becoming evident. Large commercial aircraft now fly with "graphite fins." The European A300 and A310 Airbus, DC-10, L-1011 and the newer Boeing 757 and 767 aircraft all use composite material sections. Except for the engine and landing gear, the Lear Fan 2100 jet is made entirely of carbon fibre and epoxy. The Canadian Challenger and De Havilland DCH-7 (Dash-7) have numerous composite components, and the newer Dash-8 will have significantly more.

Companies not yet involved in the design and manufacture of composite structures fear the unknown in relation to the processes required. However, such processes are actually less complex than might be expected, and they require fewer skilled employees than do many other areas of the aerospace industry. The design and fabrication of moulds, layout, cutting of cloth and layup tend to follow techniques established when fibreglass was first introduced. Essentially, the process involves building up the material through layers of "cloth," which is subjected to external pressures in presses of autoclaves. After curing, the components are trimmed, the dimensions checked, and then inspected internally for voids in the laminates. This is done by ultrasonic inspection machinery.

To help companies get involved in the design and manufacture of structures made from composite materials, Council recommends that the Department of Industry, Trade and Commerce and the National Research Council jointly establish a Technical Advisory Committee on Composites that would direct R&D funding in the manufacturing methods of this new technology and aid in the formulation of policy

and standards. The committee's efforts would cover all transportation modes, not just the air mode.

Research and Development

The requirements of small fuel-efficient jet STOL aircraft have been identified. Canadian air-frame and engine designers are capable of pursuing the R&D activities required in these areas. However, manufacturing technology and improved productive efficiencies will be necessary to compete successfully in the world marketplace. Only the larger companies have staff specialists aware of what takes place elsewhere in these fields. The industry has traditionally relied on the import of manufacturing technology, and has not shown the same success in the manufacturing of the product design as it has in the design itself. Few companies conduct process or manufacturing R&D. The few companies that do are technological leaders in the industry and have shown impressive results.

Increased automation is recognized by all as the pathway to success. Particular benefits reside in improving small batch production and in the manufacture of unique items such as tools, models or moulds. Smaller companies profit most when such items are designed, programmed and manufactured quickly and at less cost than by conventional methods.

The entire aerospace industry relies on subsidies to remain competitive in a world market where the products of other countries receive equivalent or even greater support. Assistance through the Enterprise Development Programs, the National Research Council and other government agencies has always been actively sought by members of the industry. Any substantial reduction in federal support will have to be picked up by provincial governments if a major cutback in the aerospace program is to be avoided.

Support of R&D through funding is essential, but it succeeds only in the hands and minds of highly competent and skilled people. Our aerospace companies have traditionally relied upon their ability to attract talent from overseas for much of their technical expertise. Tighter immigration laws and higher European salaries and wages have made this method less and less successful. A shortage of skills exists, particularly in the nonrecurring functions associated with engineering, manufacturing and tool fabrication, and in the recurring functions of machining and inspection.

Government assistance programs can better assist all manufacturers through recognition that CAD/CAM computer software and hardware tools are as vital to design and manufacturing efficiency as is the production machinery itself. Improvement in productivity through the automated function should form the basis of federal and provincial support, which must recognize the importance of both the manufacturing process and the design function.

The industry has recently recognized that its skilled-labour problems may be resolved through closer links with local educational institutions. Liaison with universities helps eliminate the cyclical shortage of high-level staff. However, liaison with other levels of the educational system is less easily effected. In both areas, the solutions are not short term, so industry has been forced to conduct a great deal of inhouse training. This naturally imposes a costly burden on direct productivity.

High levels of specialized automation need the support of meaningful market data to stimulate their full development. Canadian aerospace export sales have been impressive in the past five years. At the same time, a large proportion has been offset by imports, generally from the United States. Approximately 45 per cent of export sales in 1979 were offset by the importation of engine parts, air-frame parts, assemblies and equipment. This export market provides opportunities for new Canadian enterprise. Unfortunately, a detailed breakdown of import figures into meaningful categories, identifiable against manufacturing specialties, is not available. Such data would enable Canadian firms to plan their approach to capture a larger share of both a growing domestic and international market. Canadian involvement in items currently imported could include aerospace-quality aluminum, titanium and specialty steels; forgings; fibres and resins; fasteners; etched parts; and computers, including software and time-sharing services.

Council recommends that the Department of Industry, Trade and Commerce and Statistics Canada analyze the purchases made by the Canadian aerospace industries from sources outside Canada. The purpose of this investigation would be to assist in the identification of opportunities to strengthen the parts manufacturing segment of the Canadian industry.

Recommendations

Air

Decentralized management

- The Canadian Transport Commission and Transport Canada should continue to transfer management control to semiautonomous local airport authorities, and also these bodies should continue to facilitate the installation of instrument-landing systems in the smaller centres.

Safety and fuel savings

- The Canadian Air Transport Administration should investigate the feasibility of the mandatory use by Canadian airlines of electronic inflight and onground control systems and devices, in order to optimize flight routes, altitudes and approaches.

STOL

- The federal government, through the Department of Industry, Trade and Commerce and Transport Canada, should carry out a comprehensive global market analysis of the potential applications of 50-100-seat jet STOL aircraft for both passenger and light freight service.

Global markets

Canadian expertise

- If the market analysis is positive, then federal R&D funds should be made available through the Department of Industry, Trade and Commerce to refine the concept of STOL aircraft, i.e., multifoil wings, the thrust-augmentation principle, and the development of low-noise multistream engines. Such funds should be directed to the Canadian aircraft companies that are world leaders in these areas and to the National Research Council.

Strengthen parts manufacturing segment of aerospace industry

- The Department of Industry, Trade and Commerce and Statistics Canada should analyze the purchases made by the Canadian aerospace industries from sources outside Canada. The purpose of this investigation would be to assist in the identification of opportunities to strengthen the parts manufacturing segment of the Canadian industry.

All Modes

CAD/CAM

• Council recommends that domestic manufacturers become more familiar with the implications of CAD/CAM technology.

Develop expertise in use of composite materials

• To help companies get involved in the design and manufacture of structures made from composite materials, Council recommends that the Department of Industry, Trade and Commerce and the National Research Council jointly establish a Technical Advisory Committee on Composites, which would direct R&D funding in the manufacturing methods of this new technology and aid in the formulation of policy and standards.

Chapter III

The Rail Mode

The Tarnished Ribbon

Passenger trains dominated intercity movement in this country until the middle of the 20th century. However, railways played a role that extended beyond a simple carrier of people. They became an instrument of settlement and development, and they now represent an integral part of our heritage. Quite naturally, therefore, sentiment and nostalgia play a part in current public thinking about the railways.

The railways' position has undergone a severe erosion in the past 30 years. The passenger transportation "system" is now but a single spine stretched across the country, accounting for only 1 per cent of the total passenger-kilometres travelled in Canada. Once the all-purpose travel mode, it now has a significant role in only two areas: the corridor service between Québec City and Windsor, and some regional/remote services in Manitoba, Québec, Ontario and the Maritimes. In these latter regions, competition from other modes is lacking, or else the railroad is the only means of transportation.

This erosion in prominence has occurred on all fronts. The short-haul passenger market has been captured largely by the private automobile and the intercity bus. The latter offers lower fares and more frequent service, and both of them travel at higher speeds. In the 1950s and 1960s, the long-haul market was challenged by high-quality air travel. The business traveller transferred to this more attractive, time-saving mode, in spite of the higher cost.

This combination of events diminished rail patronage and in turn railways' financial viability. A point was reached when Canadian National and Canadian Pacific sought the abandonment of services in order to control their increasing losses. In 1967, the federal government, in an attempt to prevent widespread service disruptions associated with random abandonment, established service "subsidy provisions" through sections 260-261 of the Railway Act. Legislation permitted the railways a maximum subsidy of 80 per cent of the losses associated with all passenger services that were supplied in the public interest. The Canadian Transport Commission, in compliance with this legislation and at the railways' request, then declared all existing intercity passenger services to be uneconomic and thus eligible for the subsidy.

However, instead of enhancing passenger service quality and competitiveness, the subsidy led to further deterioration. The railways still regarded their 20 per cent share of service losses as an unfair burden. Without further government help or incentives, they refused to invest in passenger rolling stock or plant, thus forcing the continued operation of aged and inefficient equipment that now has to be scrapped. They paid little attention to planning and marketing their passenger services.

The situation was different in the railways' freight operations. There, altered work rules permitted cost reductions. Specifically, fireman positions were eliminated in the early 1960s and trainman positions were cut in the late 1970s. Both reductions were made because of recognized redundancy. Similar changes were not sought for passenger-rail service, despite the equal and logical applicability of such measures.

This state of affairs persisted throughout the 1970s. Revenues were far outstripped by costs associated with inefficient operating practices, the large but required amortization of capital, and inflation. As a result, deficits grew from $102 million in 1972 to $322 million in 1980. Thus, very large subsidy increments were assured. But as before, quality deteriorated further and patronage fell to even lower levels.

The federal government, meanwhile, was becoming increasingly apprehensive about the rising subsidies. In 1975, it undertook a rail policy review, and in 1976 it adopted a new Rail Passenger Policy. This policy involved service rationalization, through the elimination of CN and CP route and facility duplication; and selective upgrading of services, particularly those in the Québec City – Windsor corridor, through the introduction of high-speed Light Rapid Comfortable (LRC) equipment. Also in spite of the government's concern with the rising subsidies, the policy involved an increase in subsidy payments from 80 per cent to 100 per cent; and federal government assumption of the capital costs associated with equipment and infrastructure upgrading.

This was not as illogical as it might appear, because in 1977 the government set up VIA Rail Canada Incorporated (the vehicle through which service integration and rationalization was to take place) and this, combined with capital equipment purchases and service and marketing restructuring, was meant to stem the rising costs as well as rejuvenate passenger rail service. VIA Rail's performance in marketing its new service was remarkable. Patronage increased by 40 per cent from 1977 to 1980. However, the annual capital and operating expenditures also increased at a more rapid rate. The annual deficit has now reached $500 million, despite the discontinuance of 20 regional and local services during this period.* As a result, in July 1981, an announcement was made of the abandonment of 17 route services, the reduction of frequency in four others and the introduction of four new low-frequency day-services. Essentially, nothing will remain of the transcontinental passenger rail system network, except a single line running across the country.

Unfortunately, not even such drastic pruning as this has come to terms with the root causes of the escalating deficits. Thus, numerous

* Some of these may be considered as segments rather than entire routes.

lingering and costly problems continue to plague the system. For example, the backbone of VIA's fleet is from the steam era, so not only is it unreliable, costly to maintain and operate, but its operation practices are also dated and inefficient. In addition, there is an awkward institutional/managerial relationship, which ensures ineffective cost control and poor cost recovery. And to compound the problems, both CN and CP have not been willing to cooperate with VIA in its efforts to improve service through track upgrading, terminal acquisitions, and so on. The end result is that subsidy escalation, service deterioration and route discontinuance can be expected to continue, unless effective steps are taken to break the mould. But before the opportunities associated with any suggested major improvements in travel quality and marketability can be discussed, a clear understanding of the major problems is needed.

The Problem of Aging Equipment

After VIA Rail Canada's creation as a Crown corporation, sale agreements were drawn up with both CN and CP for the sale to VIA of their antiquated equipment. At a cost of $65.5 million, VIA acquired 1265 pieces of rolling stock. Excluding several Tempo cars and the two surviving United Air Craft Turbo Cars, now over 12 years old, the equipment had an average age of more than 27 years. VIA therefore bought a package that is becoming increasingly unreliable, expensive to operate and maintain, and inappropriate in terms of accommodating passenger demand. Each of these aspects contributes in its own way to VIA's large operating deficit.

The classic problem associated with the operation of any antiquated equipment (and even the newer conventional diesel-hauled trains) rests in the high operating ratio. Simply put, railway operating costs are greater than corresponding revenues. In addition, the relative operating cost is higher than that for competing modes, particularly the private automobile.

The cost associated with running a basic train "consist"* of one diesel locomotive and one 88-seat coach, at a realistic average load factor of 60 per cent occupancy, is 16.7¢ per occupied seat-kilometre. The cost of operating the consist is $8.95 per train-kilometre, or 10.1¢ per seat-kilometre if all seats are filled. The fixed per-seat-kilometre costs, such as those associated with crews, station expenses, fuel and maintenance for the locomotive, can be reduced by adding cars to the basic train. For example, the cost of a locomotive hauling four coaches, again at a 60 per cent load factor, falls to 6.6¢ per seat-kilometre.

* A consist is the total unit that runs on the rail line. It may be made up of a locomotive, baggage car and a number of coaches or a single self-propelled car.

Unfortunately, in 1980, the average revenue per seat-kilometre for VIA was but 3.6¢ for basic transportation.* It is not difficult to see, therefore, that a break-even performance is exceptionally difficult to obtain. For example, at a 100 per cent load factor, the operating costs of a locomotive-hauled train can only be recovered when more than 400 passengers are carried. Most routes in both Canada and the United States cannot attract sufficient ridership to generate the revenue levels necessary to meet the cost of operating the service. Adding to the number of trips in high-travel corridors, while boosting total ridership, merely dilutes per-train ridership. In fact, in most Canadian regional services linking small communities to major centres, this level of patronage is not possible for even one train per day.†

The problems are even more acute on the transcontinental route, which, in 1980, accounted for 50 per cent of VIA's total losses. Essentially, the problems arise from design inefficiencies relating to seating capacity and from the low ratio of revenue to nonrevenue cars.‡ Space in nonrevenue cars cannot be sold as it can be in revenue cars. The result is that as much as one-third to one-half of the total space on transcontinental trains does not produce revenue. Transcontinental coaches have 52 seats on day-nighters and 60-70 seats in the regular coaches; sleeping cars contain only 22-30 spaces. The latter are in a variety of accommodations including upper and lower berths, roomettes and bedrooms. The high seat-kilometre unit costs offset the additional sleeping car revenues and result in losses exceeding those of the coaches. Similarly, dining cars, as presently operated, contribute to the financial losses. If they were to recover their total cost, the prices of meals would have to double.

An alternative to the locomotive-hauled train is the self-propelled rail diesel car (RDC). It has a capacity for 88 intercity passengers and operates on a cost-per-seat-kilometre basis that is considerably below that of locomotive-hauled trains. For example, a single RDC operates at a cost per seat-kilometre of 5.9¢ at 100 per cent occupancy, and 9.8¢ at the 60 per cent load factor. However, with passenger revenues at 3.6¢ per kilometre, a break-even position is still difficult to attain. Seat-kilometre costs are reduced when a second (and third) RDC is added to the consist. Furthermore, these units, because of their seating capacity and operational flexibility, have the added advantage of being more readily tailored to the route demands than a conventional diesel-hauled train. Unfortunately, limited application of this vehicle on the North American rail system has not permitted it to achieve its full potential.

---

* This average value refers to the most economical fare arrangement available. It is the one that is most often used.

† Only one major train service in the world, the Shinkansen between Tokyo and Osaka in Japan, operates with a consistent profit.

‡ A revenue car is a coach or a sleeping car in which a seat can be sold to a passenger; whereas a nonrevenue car refers to a dining, baggage, cafe or lounge car.

Restrictions on Revenue

One way for VIA Rail to close the gap between its costs per seat-kilometre and its revenue per seat-kilometre is, of course, to raise its revenue. Unfortunately, it has little room to manoeuvre here since any attempt to increase revenue by increasing fares would likely result in lower ridership. That's because of the competition that VIA Rail faces from the private automobile. The automobile dominates intercity passenger transportation in North America, and firmly holds its ridership (see next chapter). The rail mode, to compete successfully, must be seen as a reasonable alternative to the automobile, and that means it must offer high-quality service accompanied by a fare that is marginally lower than the "perceived" cost of automobile operation.

Because it is traditional for auto users to exclude the cost of ownership, insurance, licensing and maintenance from those costs associated with any trip the "perceived" automobile cost in 1981 was approximately 5¢ per passenger-kilometre. This "perceived" cost covers the "out-of-pocket" expenses of fuel and parking only. It is considerably below the cost of operating a conventional diesel-hauled train or RDC. (See Figure III.3, p. 52.) It is impossible to charge a passenger fare on the railways that will compete with the private automobile and recover the costs of operation. Furthermore, even when the passenger fare is below the "perceived" cost of the auto, the railways are still unable to compete. For example, the 1980 average VIA Rail fare, generating a revenue of 3.6¢ per passenger-kilometre, might have been expected to lure people from the highway to the railway, but low speeds, infrequency and quality of service on antiquated rail equipment meant that VIA Rail managed to attract just 1 per cent of the intercity passenger-kilometres travelled.

Both VIA and its US counterpart, Amtrak, have therefore concentrated on raising their revenues by filling more of their trains, and they have done this by concentrating passenger demand into fewer trips. This, however, limits the number of departures: today, most routes (excluding those in the Québec City – Windsor corridor) have no more than two round trips daily. (Corridor services vary from three to seven daily trips.) These infrequent trips also must make numerous stops between terminals to serve the widest possible market. Thus, a Catch-22 situation arises, in which low frequency and slow service are traded for higher load factors. This mitigates against attracting those who use the automobile and who are accustomed to unlimited flexibility. Even the air traveller is served, in many instances, by more frequent flight departures.

Keeping the Lid on Costs

The other way VIA Rail can close the gap between revenues and costs is, of course, to reduce or at least control its costs. Unfortunately, it has had little success in this regard. For example, services in the Québec City – Windsor corridor from 1972 to 1977 experienced cost increases of 119 per cent versus a revenue increase of only 53 per cent. This dropped the ratio of revenues over costs from 53 per cent to 37 per cent.[1] The transcontinental, regional and remote services showed an even poorer performance: by 1978, these services yielded the extremely low ratios of 28, 14 and 9 per cent respectively.[2]

These rising costs and the low ratios both stem from inadequate cost control, which in turn can be attributed to a series of factors, including complex institutional arrangements, inefficient use of labour, and the differential effect of inflation on costs and revenues with the former far exceeding the latter.

In addition, almost two-thirds of the total passenger train expenses of VIA Rail are beyond its control. VIA Rail must pay CN and CP for roadbed usage, maintenance, traffic control, ownership costs of the facilities, a share of superintendents' costs, and so on. Under the Railway Act, Transport Canada cannot release details of such information, and CN and CP have refused to provide unit cost information of this type to VIA. The Canadian Transport Commission, however, does have the authority to release the information to VIA under the Railway Act, if it judges it to be in the public interest. This is an issue that is as yet unresolved between Transport Canada, the CTC and the railroads.

Labour, wages and benefits now comprise approximately one-half of train "direct" operating costs.* Current crewing practices date back to the late 1800s, when steam locomotives could operate only 160 km without refueling. Today, a typical passenger train with a locomotive and two to four cars has a complement of five: an engineer and fireman on the locomotive, and a conductor, brakeman and trainman on the coaches. The fireman and brakeman remain, although they no longer fulfill a useful role and have been eliminated from the freight side of the service. Apparently, crew reductions have not been taken by the passenger railways because government subsidies paid for 80 per cent of all losses between 1970 and 1977 and 100 per cent of them since that time. There is thus no incentive now for the railways to enter into negotiations on crewing procedures for passenger train service with the railway unions.

Working conditions also stem from the age of steam. The working day for an engineer and fireman is a minimum trip of 160 km; for baggagepersons, brakemen and conductors it is 240 km. Additional benefits must be paid if these minimum distances are exceeded.

* The remaining half is composed largely of fuel and maintenance charges.

Today's modern equipment, operating at speeds from 100 to 200 km per hour, can cover the maximum mileage for a day's pay in 2 hours or less. VIA Rail has not attempted to rationalize this costly problem.

On the transcontinental service, crewing practices and the nature of the equipment are the key elements driving the cost factors skyward. A typical transcontinental train, travelling 1400 km, has, at any given time, 21-27 crew members. The total complement is normally 47-51 people for the entire one-way trip. This crew comprises 5 engineers, 5 firemen, 5 baggagepersons, 5 conductors, 10 brakemen, 1 trainman, 4 cafe car employees, 8-10 dining car employees, 1 lounge attendant, 2 service representatives, and 2-4 sleeping car porters. This labour component alone represented more than 22 per cent of the total onboard costs in 1978. Furthermore, the labour cost for ground crews in servicing and maintaining this transcontinental equipment was 2.5 times the train crew costs.[3]

During 1972-77, rising inflation affected the cost structure of the direct and indirect services more radically than it added to the revenues received. For example, in the Québec City – Windsor corridor it accounted for $43.5 million or 76 per cent of the total cost increase during the period.[4]

The System Segments

Serious problems exist in the rail mode. Before suggesting possible remedies, a brief analysis of the system is necessary. Essentially, there are four segments to rail service, each with different characteristics. This means that there is no single simple solution. The most heavily travelled segment of the railway system is the corridor service from Québec City to Windsor. Ridership frequently approaches 300 people per trip, and in the holiday season it can exceed 700. The second segment, classified as "regional," is the service that connects communities of 20 000 – 250 000 people. It operates at average speeds of 80 km per hour, with ridership varying from a few people per trip to peaks of about 250. Such routes include Halifax–Yarmouth, Vancouver–Prince George and Winnipeg–Thunder Bay.

The services operating in the Canadian North and other remote areas, where no other modes are available, make up the third segment. They can be classified as "remote." Generally, they are operated at low speeds, and often they are integrated with freight service. In the vast majority of cases, ridership is low, ranging from 3 to 50 persons per trip. The fourth and final segment is the sentimentally popular "transcontinental" service, which today consists of only Montréal-Toronto-Calgary-Vancouver and Montréal-Campbellton-Moncton-Halifax runs. As with the other three segments, this one

suffers from low ridership, which is insufficient to meet train costs, and wide swings in that ridership, which vary with specific trains and the season.

A Rejuvenated Rail Service System

If intercity passenger rail service is to survive, then one thing that's needed is new, innovative, reliable, cost effective and cost competitive equipment.* A comprehensive analysis undertaken during this study, identified the rail equipment options that show promise of improving both service and ridership. In addition, these options could offer Canada good domestic and global marketing opportunities.

Specifically, the new equipment would have to have the following design characteristics:

a) an increased passenger capacity, which would reduce overhead costs;

b) an overall size or capacity, which would allow a more flexible system: for example, a system in which the number of seats provided on a given trip matched the number that were in demand;

c) interior arrangements that would increase labour efficiency through a larger passenger-to-crew ratio;

d) the ability to replace many locomotive-hauled consists;

e) operational characteristics of comfort and speed that would be sufficient to attract ridership from the auto and air modes.

A number of possibilities exist. The most promising options are the following:

1. The introduction of a bilevel rail car (BRC). This BRC could be either:

i) A powered BRC (PBRC), 29 m long, similar to the current rail diesel car (RDC) but with increased seating for 100-110 passengers, powered by a Canadian-made engine† sufficient to pull a trailer car at 140 km/hr;

ii) A nonpowered BRC, 29 m long, seating 130-140 passengers, hauled by a conventional locomotive or a powered BRC or repowered RDC.

---

* The electrification of the railway system for passenger service has been ruled out, largely because of the enormous capital cost (approximately $1.25 per kilometre). Other problems have also ruled out the ACE 3000, an innovative (and resurrected) steam locomotive, even though it runs on coal and incorporates all the advances in steam-power technology that have been made since the demise of the steam locomotive some 20 years ago. Also, magnetically levitated trains, or Maglevs, have been ruled out, since they are not considered economically feasible in this decade.

† For example, Cummins KTA-3067-1, V-16, 950 kW continuous.

The added seating capacity would lower unit passenger costs. The BRC would be suitable for corridor, regional or local traffic. An assessment of vehicle requirements indicates that the following would be needed:

i) 175 BRCs at $1.3 million each, for the transcontinental system;

ii) 50 powered BRCs at $2.2 million each plus 25 BRCs at $1.3 million each, for the other system segments.

This would indicate a total investment (or industrial opportunity) of $350-$400 million. The operational savings involved should allow a payback period of less than 10 years.

2. A single-level repowered rail diesel car (RDC), 26 m long, seating 88 passengers. The current version of the RDC has difficulty pulling trailers, so repowering is necessary, even at a 22 per cent interest rate.

Either the powered BRC or the repowered RDC could displace the conventional locomotive, because they essentially perform the same function but without the inherent high operating costs. They introduce flexibility into the total fleet and they improve the matching of load to demands.

3. An enlarged brakeman's coach (the final car on a freight train), making it a vehicle that could seat up to 20 passengers in relative comfort. This would allow the railways to provide passenger service on freight trains without having to add a standard passenger car. At the moment, brakeman's coaches are antiquated, poorly maintained and costly to crew.*

Figure III.1 shows the basic design features for the powered and unpowered versions of the BRC and the repowered RDC. Other arrangements are also possible.[5] Table III.1 indicates the suggested equipment substitution on the major segments of the railway system, giving a better match of capacity to demand.

Table III.2 shows the operating characteristics of various existing and suggested consist options. Typical routes for these vehicles are included. The important figures are those showing the seat-kilometre cost ratios. These train and seat-kilometre costs should be considered as indicative of the difference in costs between the equipment options under consideration. They will not necessarily match those incurred on specific actual services.†

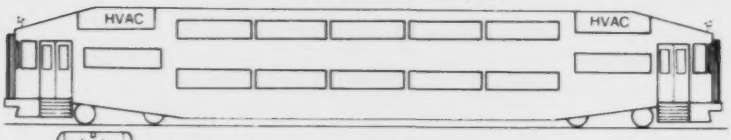
---

* Current labour agreements require the railroads to maintain brakeman coaches to acceptable standards of safety and comfort, in contrast to those for passenger coaches.

† The variations are due to the plurality of the data assimilated into the analysis, including differing terminal costs, age and maintenance costs of equipment, treatment of depreciation and the cost of capital charges, the formula used to assign costs of facilities shared with freight operations, and so on. These costs amount to 3-5 per cent of total costs, depending upon the equipment option chosen.

Figure III.1 – Intercity Passenger Rail Vehicles

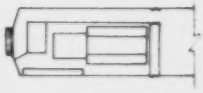
Double-Decker Nonpowered (Trailer) Car



Length 29 m
Width 2.9 m
Height 4.87 m
Weight 68 000 kg
Truck centres 19.5 m

Capacity 132 seats
Cost $1 300 000
Comments To be pulled by locomotive or by PBRC

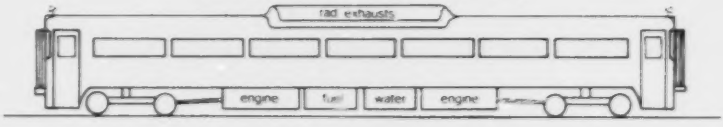
PBRC – Fishbelly Double-Decker Diesel-Electric Car



Length 30 m
Width 2.9 m
Height 4.87 m
Weight 72 800 kg
Truck centres 19.5 m

Capacity 118 seats
Power Cummins 3067 V-16 engine, 970 kW
Cost $2 200 000
Comments Can pull trailer at 120 km/hr

(Existing) Refurbished Rail Diesel Car (RDC)



Length 25.9 m
Width 3.2 m
Height 4.45 m
Weight 63 700 kg
Truck centres 18.2 m

Capacity 88 seats
Power 2 x Cummins 14.1 l engines, 506 kW
Cost $1 800 000
Comments Not designed to pull a trailer

Table III.1 – Suggested Equipment Substitution

Service Category	Existing Equipment	Proposed Equipment
1. Transcontinental e.g., Montréal-Vancouver and Montréal-Halifax	Conventional locomotive-hauled consists on both Eastern and Western Transcontinental	*1)* Bilevel consists hauled by locomotive on Western Transcontinental
2. Corridor e.g., Toronto-Windsor and Montréal-Ottawa	*1)* Conventional locomotive-hauled consists *2)* Turbo trains on express runs only *3)* Occasional RDCs in local service	*1)* LRC trains on express runs only *2)* Repowered RDC or PBRC combinations on high-speed express runs *3)* RDC or PBRCs hauling BRCs on semi-express and local runs
3. Regional e.g., Halifax-Yarmouth and Victoria-Courtney	*1)* Conventional locomotive-hauled consists *2)* RDCs in single and multiple car consists	*1)* High-powered RDCs or PBRCs hauling a trailer on heavy ridership routes
4. Remote e.g., Winnipeg-Churchill and Rouyn-Senneterre	*1)* Occasional conventional locomotive-hauled consists *2)* RDCs, single and multicar *3)* Mixed train consists	*1)* High-powered RDCs alone or hauling a trailer when high capacity is needed *2)* Existing refurbished RDCs on other routes *3)* Passengers carried in an enlarged brakeman's car* *4)* Railbuses†

* Not operated by VIA, but by freight carriers.
† If CTC willing to waive structural and safety requirements pertaining to conventional passenger cars.

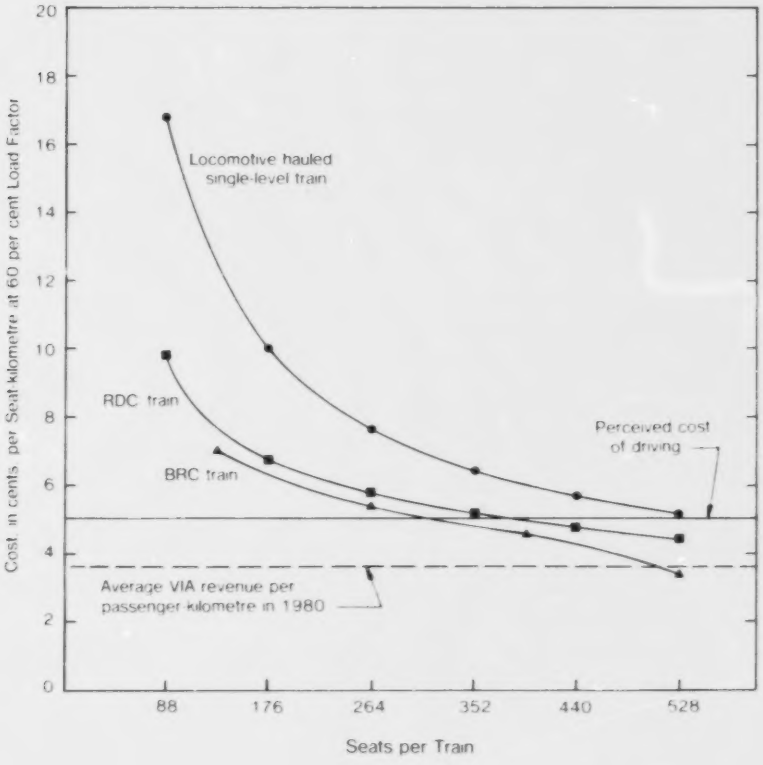
These suggested equipment options yield lower seat-kilometre costs without changing current crewing practices. RDC and BRC vehicles both require one driver and one conductor per car. A major improvement therefore results from the removal of the locomotive as the propulsive vehicle. A two-car, locomotive-hauled consist requires seven people: a driver, a fireman, two conductors, a trainman, a snack-bar attendant and a waiter. A single self-propelled BRC, equipped with a self-service snack bar, may be operated by only the driver and the conductor. In other words, crew reductions would be achieved even though crewing practices remained unchanged. Further crew reductions could be realized by designing the car for one-person operation, assisted by an automatic pilot control. On the transcontinental train, double decker or bilevel designs would permit maximum space utilization in sleeper cars, coach cars, and the diner/cafe/lounge cars. Scheduling could allow laundry and meals to be prepared "off route" and picked up at appropriate times; this would

Table III.2 – Equipment Options Potential for Cost Recovery

Consist	Maximum Capacity	Operating Cost per Km($)*	Seat Cost Km (¢) at 60% Load Factor	Seat-Km Cost Ratio	Possible Savings (%)	Typical Routes
locomotive + 2 cars	176	10.60	10.0 (108)†	100	0	Moncton-Campbellton
2 RDCs	176	7.10	6.7 (108)	67	32	
1 Bilevel RDC	132	5.60	7.9 (80)	70	30	
1 Bilevel RDC	132	5.60	5.3 (108)	53	45	Victoria-Courtney
locomotive + 3 cars	264	12.20	7.6	100	0	Montreal-Ottawa
3 RDCs	264	9.60	5.9	78	22	
2 Bilevel RDCs	264	8.60	5.4	71	29	Halifax-Yarmouth
locomotive + 4 cars	352	13.70	6.5	100	0	Montreal-Toronto
4 RDCs	352	10.60	5.1	79	21	
3 Bilevel RDCs	396	9.90	4.6	71	29	Toronto-Windsor

* This does not include depreciation and the cost of capital expenses for equipment. For the new equipment options suggested, the capital cost, on a seat basis, is no greater than that of the replacement of the current antiquated equipment by single-level vehicles.
† Figure in brackets is number of persons.

Figure III.2 – Cost Curves for Locomotive-Hauled, RDC and BRC Trains in Consists up to Five Cars



further reduce operating costs and improve space utilization. The calculations of Table III.2, however, are not based on such changes in current crewing practice. Any changes would require new VIA-union agreements.

The introduction of bilevel or high-capacity cars into the existing intercity passenger rail network could potentially reduce net deficits in the system by as much as 20-30 per cent or $70-$100 million, annually. The lowering of costs, although laudable, does not ensure that a railway system can operate at a profit. Revenues must still exceed expenditures. The relationships between the number of revenue passengers and the operating costs for various types of transit are shown graphically in Figure III.2 and schematically in Figure III.3. The revenue necessary to provide a break-even operation at two fare levels is indicated. The cost curves for locomotive-hauled trains,

RDCs and BRCs clearly indicate that the first two cannot provide a profitable operation, when the average revenue per passenger seat-kilometre is slightly less than 3.7¢. The BRC train does show a substantial reduction in cost per seat-kilometre over a locomotive-hauled consist; it also shows a better performance than the RDC.* Obviously, even under the best conditions it is necessary to raise revenue or to add more cars per train. It is reasonable to assume that the upper limit of passenger fares might be that approaching the "perceived" cost of travel by private automobile, or approximately 5¢ per passenger-kilometre. If so, Figure III.2 clearly shows that the locomotive-hauled train would require five cars, at an approximately 64 per cent load factor, to cover expenses. This type of passenger demand is rare in Canada. However, a BRC train of two cars operating at this load factor does have the potential to show a profit.

Council, therefore, recommends that:

1. VIA Rail and the equipment manufacturers, along with Transport Canada and the Department of Industry, Trade and Commerce, undertake further R&D on new railway vehicles including the following:

i) the bilevel rail car, both self-propelled and nonpowered (even an articulated version);

ii) the repowering of the rail diesel car;

iii) the application of the brakeman's coach to passenger service.

2. That, consistent with these R&D programs, VIA Rail should develop a comprehensive rail-passenger-system simulation, against which the parameters of the proposed vehicle design options (and other alternatives) can be tested.

3. In addition, VIA Rail, CN, CP, Transport Canada, the Canadian Transport Commission and the labour unions should jointly undertake a study of general operating practices, in light of the proposed addition of the new equipment options to the railway fleet. Such a study should include the following:

i) a complete reassessment of broad crewing practices for both existing and new equipment;

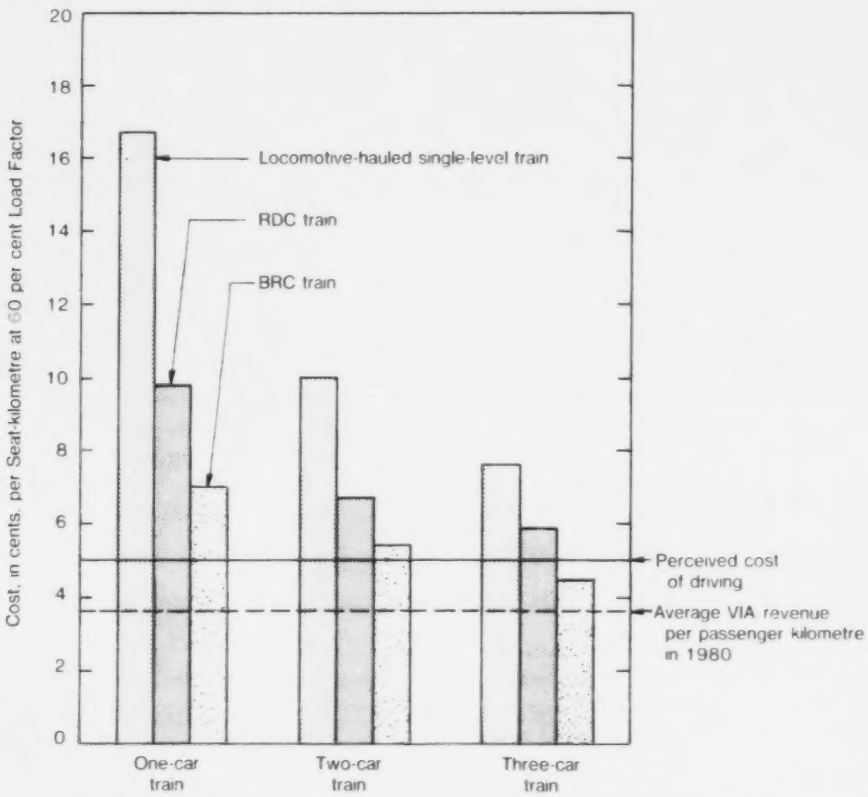
ii) the operational elimination of locomotive-hauled consists on local, regional and corridor routes;

iii) the provision of passenger-train track priority during daily peak travel times;

iv) the identification of cost-saving initiatives, such as the use of nonrevenue space on transcontinental trains and the optimal use of dining facilities on all segments of the system; and

* For example, a consist of two BRCs will carry an equal number of passengers as a locomotive-hauled consist of three cars or three RDCs, and operate at a 29 per cent cost saving over the former and a 9 per cent cost saving over the latter.

Figure III.3 – Seat-Kilometre Costs at 60 per cent Load Factor for BRC, RDC and Locomotive-Hauled Trains



c) an investigation of new ways to generate revenue using passenger-transportation equipment, for example, by introducing small parcel service on the new bilevel rail cars.

4. Finally, Council recommends that the Standing Committee on Rail Passenger Transportation and the Railway Transportation Comprehensive Audit (among others), which are investigating the institutional and legislative framework within which VIA Rail operates, take full account of these recommendations.

Recommendations

Rail

Survival of intercity passenger rail service

• VIA Rail and the equipment manufacturers, along with Transport Canada and the Department of Industry, Trade and Commerce, should undertake further R&D on new railway vehicles including the following:

New equipment needed

i) the bilevel rail car, both self-propelled and nonpowered (even an articulated version);

ii) the repowering of the rail diesel car;

iii) the application of the brakeman's coach to passenger service.

All options tested

• Consistent with these R&D programs, VIA Rail should develop a comprehensive rail-passenger-system simulation, against which the parameters of the proposed vehicle design options (and other alternatives) can be tested.

Review of general operating practices

• In addition, VIA Rail, CN, CP, Transport Canada, the Canadian Transport Commission and the labour unions should jointly undertake a study of general operating practices, in light of the proposed addition of the new equipment options to the railway fleet. Such a study should include the following:

i) a complete reassessment of broad labour practices for both existing and new equipment;

ii) the operational elimination of locomotive-hauled consists on local, regional and corridor routes;

iii) the provision of passenger-train track priority during daily peak travel times;

iv) the identification of cost-saving initiatives, such as the use of nonrevenue space on transcontinental trains and the optimal use of dining facilities on all segments of the system; and

v) an investigation of new ways to generate revenue using passenger-transportation equipment, for example, by introducing small parcel service on the new bilevel rail cars.

Results of proposed research study be utilized

• The Standing Committee on Rail Passenger Transportation and the Railway Transportation Comprehensive Audit (among others), which are investigating the institutional and legislative framework within which VIA Rail operates, should take full account of these recommendations.

Chapter IV

The Auto Mode

The Ubiquitous Automobile

The automobile is undoubtedly the product of technology that has had the most sustaining influence in changing North American society. Nikolaus Otto invented the reciprocating engine 103 years ago, and Daimler and Benz introduced gasoline as its fuel, with Diesel adapting it to compression ignition. But it was Henry Ford who first gave America "wheels" and conferred on us an individual mobility never before known. At first an oddity, then a status symbol and now a necessity for both business and recreation, the automobile invades every aspect of our lives. Not unexpectedly, it also dominates the intercity travel mode. It is the benchmark used to measure the appeal of other modes of intercity travel, especially for journeys under 800 kilometres. It is used in almost 4 out of every 5 passenger-kilometres travelled.

The dominance of the automobile is not difficult to understand. Its "terminal" is its owner's driveway; its freedom of movement is unrestricted through a huge highway network; its convenience is unparalleled for multipurpose business and pleasure travel. It competes successfully with other public surface modes in elapsed journey time and it is perceived to be cost effective. It is without threat of driver strike and operator rudeness. Most importantly, it is often the only mode available.

During the third quarter of the 20th century, this dominance was reflected by the number of automobile registrations in Canada: they grew by 450 per cent from 2 to 9 million, with personal-use vehicles reaching 7 million. By 1975, four out of every five households owned a car.

The personal car owner generally sought style, comfort and safety. The last was interpreted in terms of vehicle size and engine power. Strong competition among North American manufacturers provided abundant choice, many extra options and wide price ranges. To be unsatisfied with one's selection of a new car was almost a reflection of one's intelligence. The first model purchased often claimed lifelong allegiance. Foreign cars were perceived as luxury items or sport models, becoming symbols of prestige (or, in the case of the "Beetle," of inverse snobbery). Little concern was felt for the environment; leaded gasolines simply made the engine knock-free. The price of gasoline was not a concern; nor was its availability. The average life of the car was 8-10 years, and there was a good market for second-hand vehicles. Prices were reasonable and, over the quarter century, rose less than the cost of living.

However, the automobile was not without its problems. Environmental concern forced the introduction of expensive pollution-control equipment and expensive lead-free fuel. People began to speak out about the quality of the product through the "Nader movement."

Conventional wisdom turned to a belief that quality lay in a foreign-built car. Numerous road tests in popular magazines endorsed this view. On top of it all, in November 1973, the OPEC (Organization of Petroleum-Exporting Countries) nations embargoed oil, and fuel prices rapidly rose. Vehicles built in North America had lower fuel economy than those built overseas – especially those built in Japan. The extensive penetration of the North American market by small, more fuel-efficient, foreign cars began.*

The Growth of the Auto Mode Since 1974

Surprisingly, despite the threat of an energy shortage that followed the OPEC embargo, automobile use continued to grow in Canada at an annual rate of 3.5 per cent. Granted, this was one-half the traditional annual growth, but it was maintained in spite of price increases. The US experience was somewhat different. Drivers experienced an actual shortage of gasoline in 1974, and, after the Iranian crisis, a modest rationing program led to an overall decline in fuel consumption. That trend appears to be continuing into the 1980s. Also, the cost of gasoline rose rapidly in the United States; whereas in Canada it was artificially held down by the government.

Rural and intercity auto passenger transportation in Canada still uses about 11 per cent of our total oil production. It also carries about 145 billion passenger-kilometres per year. The yearly increase of 3.5 per cent therefore amounts to about 5 billion passenger-kilometres per year. This increment alone is greater than the *total* amount carried by the bus industry, and is almost double the *total* carried by rail. As a result, a future energy crisis could not shift even the annual growth of auto travel to the other surface modes: it would require an increase in their capacity that would be impossible for their equipment and infrastructure to accommodate.

Despite energy constraints since 1974, the automobile has continued to gain an increasingly larger share of the transportation market. It has captured approximately two-thirds of the annual growth, with the other third going to air travel. At a time of energy conservation this is not happy news.†

---

* The percentage gain in Canada has been somewhat less than for North America as a whole; traditionally more small foreign cars have been purchased by the Canadian buying public.

† It is generally assumed that any shift from the automobile to the airplane adversely affects energy efficiency. However, caution is needed in such generalizations. For example, Barton has shown that if the airlines fill empty seats with people who would otherwise have used their cars, there is a net energy saving. It would also be more energy efficient to use a fully loaded B737 on the Halifax-Sydney route or the Calgary-Edmonton route than to haul the same load using certain automobiles with various load factors. A loaded B737 is certainly more energy efficient than a series of fully occupied "gas guzzlers" or a series of singly occupied energy-efficient automobiles.

It must be emphasized that the car driver makes choices that balance the perceived additional costs of using a car against personal strain, but not wear and tear on the car. On this topic, the driver received contradictory signals in the immediate past. On the one hand, she or he was aware that public transportation was more energy efficient; but on the other, the low incremental operating costs were an incentive to use a car. With two passengers, the energy factor became less significant and the cost factor became strongly in favour of the private vehicle.

The Decline of the Auto Industry

Although the auto gained ground in terms of its use, the North American (and Canadian) auto industry did not. In a reaction to the fuel crisis of 1974, the North American public demanded smaller cars that would save them gasoline, and the manufacturers moved to satisfy that demand. However, after the initial concern passed and gas again became available, the public turned back to larger, stylish vehicles. Detroit, understandably (though, in hindsight, foolishly), postponed or dropped its plans to introduce fuel-efficient small cars; it allowed the foreign manufacturers, principally the Japanese, to be the only ones ready with such vehicles when the crisis returned. (North American attempts to produce a fuel-efficient diesel-driven vehicle also stalled.) When the crisis did re-emerge, there were few North American small-car models, and those that did exist were felt to be uncomfortable, unstylish and pricey. This made them poor competition for the imports.

As a result, the profits of all North American manufacturers turned into losses that were staggering. Industry-wide, those losses reached almost $2 billion in 1980. At the same time, the penetration of the North American car market by foreign vehicles continued its dramatic climb – from 5 per cent in 1971, through 15 per cent in 1976 and 20 per cent in 1979, to 27 per cent in the model year of 1981. That penetration came mainly from the Japanese (22 per cent); the rest came from Germany (3 per cent), the USSR (1 per cent), and all other countries (1 per cent).

On a worldwide scale, 1980 marked the first year in which the total auto production of Japan exceeded that of North America. This transfer of positions is particularly startling when the actual numbers are compared. In 1979, North America produced 13.1 million cars; in 1980, the number was 9.4 million.* Japanese production in 1979 was 9.6 million; in 1980, it was 11.0 million.

* Due primarily to poor economic conditions, sales will not reach 7 million in 1981.

The Changing Automobile and the Changing Fleet

The number of cars in the Canadian automobile fleet is expected to grow by 2 per cent per year during the 1980s. That means the fuel efficiency of the fleet must improve by 2 per cent per year, if consumption is to remain stable at around 244 million barrels of oil per year. (This assumes no drastic change in the pattern of vehicle use.) Drivers now tend to emphasize saving money on travel costs and not the conservation of energy; thus, although a driver may prepare for an eventual fuel crisis, he or she is unlikely to act until a real shortage arises. Change can occur, however, as was shown in the United States during the 1979 gasoline shortage. Then, the major reason people decided not to use their car was uncertainty about the availability of gas for the return trip.

The two related pressures, supply and the cost of fuel, are powerful motivating factors for an owner to demand a more fuel-efficient vehicle. However, if a driver owns a large "gas guzzler" that is driving up transportation costs, he or she must weigh those costs against the immediate payout of capital for a new car and the high cost of borrowing some of that capital. In addition, an older car is now almost worthless on the used car market. More and more drivers are thus reaching a compromise by driving their older cars until they are almost unserviceable. The "replacement cycle" in North America has, as a result, fallen from three to two purchases per decade. These pressures will undoubtedly continue well into the 1980s, and at mid-decade will cause a relatively large demand for new fuel-efficient vehicles. The replacement cycle should then return to "normal." These changes will have a major impact on the kinds of cars that will be available in the next 10 years.

Today's baseline vehicle-mix provides a fleet generally capable of seating five or more passengers per car, with appropriate luggage space. Average gasoline consumption is 16.2 litres per 100 kilometres.* This average, however, masks a large difference in types. First of all, there are the conventional, large North American-built vehicles carrying six passengers and achieving a fuel rating of about 17 litres per 100 kilometres. Most of these cars were built prior to 1978 and they represent a diminishing portion of the total fleet. Secondly, there are the more fuel-efficient vehicles, generally front-wheel-drive units giving a consumption of about 11 litres per 100 kilometres. Because of the front-wheel-drive configuration, these cars are able to give a passenger compartment that is not much

* This 1980 annual figure increases to 18.2 litres per 100 kilometres during the Canadian winter.

smaller than the full-size vehicles.* This smaller group provides an average fuel efficiency that is 20-25 per cent better than the conventional vehicles in the fleet. Thirdly, there are the smaller, highly fuel-efficient vehicles dominated by imports, particularly from Japan. These imported cars, together with the newest small North American vehicles, made up about 41 per cent of the Canadian new-car market in 1980. As a class, they are almost 50 per cent more fuel efficient than the stock of all older vehicles.

The North American manufacturers have announced plans for changes in the vehicle-fleet mix by the end of the decade. These plans have been revised in each of the past three years to include ever larger proportions of smaller cars, and it is as yet difficult to foresee what the total market will be in 1990. It is almost certain, however, that four-cylinder cars will dominate the market completely. Today, no three-cylinder engines are produced; but General Motors anticipates 3 per cent production by 1990, and it may be forced to introduce a much larger proportion even earlier. Thus, the current General Motors forecast for decade-end of 40 per cent four-passenger or less, 40 per cent five-passenger and only 20 per cent six-passenger, may well have to be further reduced.

In spite of these changes, the power plant for the next one or two decades will still be a reciprocating internal combustion engine run on ordinary gasoline, diesel fuel or (with slight modifications), gasohol or even compressed natural gas.† Gas turbines require advances in heat-transfer reduction through high-temperature ceramic components, which, if developed in the 1990s, will benefit the reciprocating engines as well.‡ Electric battery technology is possible for light, urban vehicles, but requires a major technological advance to improve the efficiency of the electrochemical processes before it can be considered a candidate for intercity propulsion.

However, one radical change that will take place is that onboard microprocessors will monitor and control the operation of a number of independent parameters, such as the spark advance, air-fuel ratio,

---

* For example, the Chevrolet Citation interior is 2.7 cubic metres; whereas that of a Chevrolet full-size vehicle is 3 cubic metres (2 doors) and that of a Malibu 2.7 cubic metres (2 doors).

† Alternative fuels (gasohol or ethanol in gasoline or natural gas) will suffer the disadvantage of not having an infrastructure in place for distribution. The recent experience in Brazil of alcohol-fueled cars becoming increasingly troublesome to operate and service has turned many early customers back to gasoline-powered automobiles. Hydrogen is the most exotic newcomer to this list and is being tested by Daimler Benz in Germany. It is released as needed from a hydride compound, and is burned to only one nonpolluting product, water. The hydrogen initially could be generated from water using surplus electricity in off-peak hours from hydro or nuclear power plants. It, too, would require an entirely new fuel distribution infrastructure at large capital cost.

‡ Isuzu Motors and Kyoto Ceramics announced in January 1982, a three-cylinder, 2-litre engine using ceramic materials. It apparently does not need a cooling system and achieves a 30 per cent greater fuel efficiency than conventional cars of similar size.

the exhaust gas recirculation, and the load and the speed of the vehicle. In addition, these microprocessors will perform a variety of other functions, with the limit being set only by the ingenuity of the designer: for example, air conditioning that adapts itself to the weather, automatic adjustment of the suspension to match the load, automatic windshield wipers switching on at the moment rain begins, digital dashboard displays with voice synthesizers warning of low fuel and other problems, antilocking brakes, digitally locked doors – the list is almost endless.

These controls will be placed in vehicles that weigh a great deal less than the average of the current vehicle fleet, even though downsizing has already been substantial. For instance, the average weight of a North American car in 1975 was 1.8t; in 1980, it was 1.4t; and by 1985, it will most likely be about 1.09t.* This weight reduction will be effected by the use of high-performance steels (lighter and stronger than those now in the vehicle), the increased use of aluminum and the widespread introduction of composites. It is quite easy to envision the upheaval that is occurring within the automobile manufacturing industry. Never before have such drastic changes been called for. New engine plans, new body designs and new automated factories must be built at enormous capital outlay in an era when sales are depressed. Little capital is being generated internally, and the recent high interest rates make the race to compete with the Japanese imports a difficult and traumatic one.

The Canadian Auto Industry

An indication of some of the changes that lie ahead has been given. But crucial questions remain. Who will produce the cars that North Americans (and particularly Canadians) will buy? Where will the plants be located? What can be done to insure the maximum share for Canada of the new technology? Answers must recognize the structure of the Canadian industry as it now exists.

Simply put, there is no Canadian automobile industry in the sense that there is one in, say, Germany, Japan or France. There is a North American industry of which ours is only a 10th part. As far as vehicle manufacturers are concerned, there are only three majors: General Motors, Ford and Chrysler. Others have small assembly operations.

The Canadian industry is governed by the Canada-US Automotive Production Trade Agreement of 1965 (commonly called the Auto Pact). The Auto Pact acknowledged formally what had been the reality for many years: the industry producing passenger and com-

* The initial cost of the new materials may, however, place a price penalty on such vehicles and slow their introduction.

mercial vehicles in Canada is not separate from the industry in the United States in the same way as the industry is in, say, Britain, Germany or Australia. In those countries, a combination of geographic, cultural and economic factors make for a high degree of "separateness," in spite of a vehicle production that is dominated by subsidiaries of General Motors or Ford.

The Auto Pact provided for conditional duty-free trade between Canada and the United States on assembled vehicles and original equipment parts. It related the sales value of vehicles sold in Canada (imported duty free) with the sales value of vehicles manufactured (assembled) in Canada. In other words, if Vehicle Company A sells vehicles valued at X dollars in Canada in any one production year, then during that year it is required to produce vehicles worth a designated proportion of that value (not less than 75 per cent) in its Canadian plants. The pact focussed on the ratio of the net sales value of vehicles "sold" to vehicles "produced" in the base year of 1965, and that ratio is the minimum designated value that has had to be maintained by the vehicle companies in subsequent years. The "value added" and the vehicles produced (or assembled) in Canada must be at least as great in absolute terms as in the base year, and at least 60 per cent of the growth in value of passenger vehicles sold has to have matching Canadian value added.

Two consequences stem from the closeness of the Canadian and the United States' markets. The first is the similarity or even identity of products found acceptable by the two, making it unnecessary (or at least uneconomic) to attempt to develop a unique product for Canada. The second is that complete integration under the Auto Pact has placed the decision-making locus in the United States. This combination provides us with a wide variety of choice of vehicles, but the conceptualizing, designing and engineering is largely done elsewhere. The complete North American car is not imported as is the Japanese or German vehicle, but the creative functions are.

General Motors (along with other vehicle manufacturers) has claimed that product design engineering has to be centralized in order to preserve final product integrity. But only 31 per cent of the members of the Society of Automotive Engineers (SAE) employed by US General Motors are in the vehicle business division; fully 42 per cent are employed in parts manufacturing divisions, which are scattered at distances that frequently exceed the distance from, for example, Detroit to Oshawa. The decision to centralize engineering design is therefore a discretionary corporate one and does not appear to depend upon any mystique of automobile building. General Motors Canada has less than 1 per cent of the total SAE membership involved within all General Motors engineering.

Under the Auto Pact, the Canadian auto industry has therefore become little more than an assembly operation purchasing offshore

engineering expertise. These issues are clearly argued in a series of studies[1] that show the loss of responsibility for the R&D of vehicles. Equally important, it resulted in the loss of 2800 engineering and senior technical staff positions.*

The Auto Pact relates sales *value*, not units produced or imported. Therefore, one expensive vehicle produced here would permit the importation of two, three or even four smaller, lighter and cheaper vehicles. Unfortunately, employment is not directly related to vehicle value, since it takes about the same number of workers to produce either the more expensive or the cheaper car. This has hurt Canada, because often the larger, more expensive cars have been produced here.

Not all aspects of the Auto Pact are negative, however. First of all, the pact removed the need to produce the entire range of passenger vehicles in Canada. It produced a continental industry, with production decisions that were made rationally. As a result, Canadian production costs dropped to the levels in the United States. At the same time, there were large increases in the number of people employed in the Canadian industry.

By 1977, vehicle production in Canada had increased by 170 per cent over 1964; parts production was up by 800 per cent; Canadian value added by 400 per cent. Meanwhile, the price differential was reversed, so that, by 1979, the Canadian selling price was below the US selling price (adjusted for exchange). The pact may well have been the best agreement that could have been negotiated in 1965. Yet irritants continue to exist, particularly in the imbalance of trade and the adverse effect on the independent parts manufacturers in this country.

The Independent Parts Manufacturers

The structure of that segment of the industry dealing with the manufacture of parts (not connected to the assembly operation) is significantly different in Canada than it is in the United States. Here, only 25 per cent of vehicle manufacturing is based on inhouse parts. In the United States, the figure is double that amount. Thus, independent parts manufacturing is proportionately much more important in Canada. Also, when it receives an order, that order is to supply *all* of

* The argument has also been generalized to include 19 000 employment positions in the automotive industry in Canada. It may not, however, be rational to argue that these are incremental positions lost to Canadian employment as the assembly process may not have been as extensive under some other agreement. Without question, however, the skill level of the positions within the domestic industry has been affected. An analysis of 1976 data shows three-quarters of the direct labour work force in Canadian vehicle manufacturing is classed as nonskilled versus one-half of the equivalent work force in the United States.

the North American market. The border is no longer a barrier. The typical Canadian parts manufacturer, whether Canadian or foreign-(generally US) owned, has the requisite product-development test equipment to meet the competition from any location. It represents the portion of the industry that employs proportionately more people than are employed in the United States. Parts manufacturing is Canada's most important sector of the automotive industry.

The World Car

The most recent corporate move in the automobile industry has been the introduction of the "world car." This is a more radical idea than simply shipping similar vehicles across national boundaries.* Parts for this car, assembled in North America, could be made in Europe; equally, some parts assembled in Europe, could be made in North America. The economies of scale in manufacturing overcome the cost of transportation and inventory to the point where the final product, regardless of where it is assembled, often uses only one source for each part.

Some components are obviously candidates for large-scale production in one facility. These would include engines and transmissions, and transaxles for front-wheel drives. Other components, particularly body stampings that make up the vehicle body itself, do not travel well without expensive packing costs. Stampings are easily damaged and can become corroded in transocean voyages; they would be made regionally, close to the point of use.

Under the Auto Pact, parts produced anywhere in the world may be imported duty-free into Canada by the car manufacturer that qualified under the pact. Therefore, a US manufacturer, although having to pay relatively high duty on parts entering the United States,† can import those parts into Canada and assemble the vehicle here. Provided the final vehicle has the required 50 per cent North American (US and Canadian) content, it could enter the United States duty-free. It therefore makes a great deal of sense for the manufacturer of a world car to source its engine and transmission and other parts in, say, low-cost Mexico or Brazil and to assemble the completed vehicle in Canada.

Mexico will be producing some 3.5 million four-cylinder engines by 1985, of which 2.5 million will be shipped north. In addition,

---

* The concept has been approached differently in North America than elsewhere. General Motors and Ford have had worldwide production facilities for parts and vehicles for a number of years. Their concept of a world car was introduced to maximize profits from the more efficient use of plants. The Japanese opening of plants in Italy, England, the United States and Mexico is primarily intended to avoid penalties through import duties.

† This duty can be (and has been) waived or reduced to the very low level of the duty on finished vehicles entering the United States.

another 1 million four-cylinder engines will likely be brought in from Brazil. It seems unlikely that all those engines will be assembled into cars in Canada, although many will. More importantly, though, with the volume of imports, there will be no necessity for Canada to produce any. The Auto Pact made the Canadian auto industry essentially an assembly operation. The "world car" is likely to strengthen that position.

Given the present state of the North American auto industry, it is almost impossible for Canada to negotiate a better position within the Auto Pact. So what is the best approach for Canada to take? Before attempting to answer that question, the full dimensions of the problem must be clearly understood. In reality, the disadvantages of the Auto Pact and the world car only become major problems when the competition from the Japanese auto industry is taken into account. That's because we have become part of a global, not a continental, auto industry.

The Japanese Advantage

The rapid penetration of the North American market by Japanese vehicles is the result of three factors: (*a*) lower production costs (greater profits); (*b*) higher perceived quality of the vehicles produced; (*c*) lower vehicle operating costs (better fuel efficiency). A number of studies over the last two years[2] have identified a cost advantage to the Japanese, which enables them to produce a car more cheaply than the equivalent car could be produced in North America. Although the data are not entirely precise, they are undoubtedly right in direction. They indicate that, on average, the Japanese produce a modern car at about $1500 less than do North Americans. The change in this price comparison for the past three years is shown in Table IV.1.

This table disguises the larger proportion of big American cars included in the "average." However, not all Japanese vehicles are small. Japanese cars are now produced in a wide range of sizes which appeal to many market segments. Also, they sell in different propor-

Table IV.1 – Comparison of Average Prices of North American, Japanese and European Cars Sold in Canada, 1978-80

	1978 ($)	1979 ($)	1980 ($)	Increase, 1978-80 (%)
North American	6 596	7 359	8 193	24.2
Japanese	5 066	6 387	6 619	30.1
European	7 162	8 037	10 074	40.3

Source: Statistics Canada, *Globe and Mail*, Toronto, 12 March 1981, p. B3.

tions in Canada than they do in the United States, with a much higher proportion of the lower cost vehicles being sold in Canada.

A number of reports on the North American industry have compared productivity and costs on this continent with the same factors in Japan. A working paper prepared for the Transportation Committee, made available by Council in November 1980, identified a productivity of 24 vehicles produced per person-year in Japan against 13 in North America. The Goldschmit study, prepared for the US Secretary of Transportation, identified differences in landed costs of between $1000 and $1700, even after duty and ocean transportation had been paid.

The most recent analysis was published by Abernathy and others of Harvard. It relates differences in person-hours required to produce comparable vehicles in the two countries, and it finds that labour savings occur in the technology of stamping (changing of dies); lower inventory costs ("just-in-time" production); improved quality-control systems; the use of "quality circles" to involve workers in what is happening in the work place; the much smaller sizes of plants in Japan; the area of union management relations; and the lack of unplanned absenteeism in the Japanese plants.[3]

Of course, two "average" vehicles from two countries are not necessarily the same. However, in the most recent work by Abernathy, Clark and Kantrow,[4] such items as product mix and the differences in degree of vertical integration in the industry have been taken into account in the calculation of price advantage. Regardless of the stress placed on the various items, significantly lower costs appear to characterize the Japanese automotive industry. And all the evidence shows that Japanese companies are highly profitable, while North American companies have been losing large amounts.

Coupled with the cost advantages outlined above, there is a customer perception that the imported Japanese vehicle is superior in quality to the North American one and requires fewer repairs. Table IV.2 distills popular US opinion and shows that all vehicles rated below average were North American, whereas all vehicles rated much better than average were imports.* This is a severe handicap for North American automotive producers to overcome.

A key factor in achieving high productivity and quality is the attitude in the work place. Many visitors to Japan (and Germany for that matter) are struck by the attitude of the workers towards their work, not just in the automotive industry but generally. Pride in a job well done, shame with something imperfect, and a feeling of involvement and responsibility are all very noticeable.

---

* Quality control is apparently much better assured by worker-initiated line stoppages, bringing to everyone's attention an inferior part or process. This concept of *Jikoda* appears to ensure that the finished vehicles are all of similar and superior quality.

Table IV.2 – Ratings of Overall Vehicle Quality, 1979 Passenger North American and Imported Products, by Members of Consumers' Union

Ratings (in comparison to average)	North American	Imports	Total
much better	0	17	17
better	11	2	13
average	26		26
worse	8		8
much worse	10		10
Total	55	19	74

Source: Consumers' Reports, Consumers' Union of the United States, Mount Vernon, NY, April 1980, pp. 263-272.

The third factor responsible for high import sales is the perception that fuel consumption in foreign cars is less than that of domestic models. A complete comparison of cross vehicle mix is not possible, because the Japanese (and European) cars do not generally compete with the larger North American cars. However, Table IV.3 shows average fuel consumption for the past two years. Fuel efficiency of North American vehicles is improving rapidly, much more so than that of European vehicles, but still less rapidly than that of Japanese ones.

Automotive Employment

Future employment in the automotive industry must be analyzed in the light of (*a*) probable production levels; (*b*) the productivity increases likely to be induced in the North American industry by import competition; (*c*) the existence of extensive "offshore" procurement policies associated with the the world car. On the assumption that the total proportion of the Canadian market captured by offshore (primarily Japanese) imports will vary from a low of 10 per cent to slightly above its current 30 per cent, estimates can be made of the

Table IV.3 – Average Fuel Consumption of North American, Japanese and European Cars in 1980 and 1981

	1980	1981
	(L/100 km)	
Minicompacts and Subcompacts		
North American	8.7	8.1
Japanese	8.2	7.1
European	8.1	7.6
Compacts and Midsized Vehicles		
North American	10.1	9.1

number of cars that will be sold here during the rest of this decade; hence the number that will be made in North America.*

Over the past several years, the Canadian proportion of employment in the North American automobile industry has remained relatively constant at about 11 per cent. Knowing the number of vehicles to be produced, we may assume either the historic productivity levels of the domestic industry stay the same, or the industry will approach current Japanese levels. One recent extensive study for the Task Force on Labour Market Development[5] assumes that, by 1985, North American productivity will be 85 per cent of the 1980 Japanese productivity. This leads the study to conclude that employment in the Canadian automotive industry will be 67 000 – 73 000 in 1985 and 50 000 – 55 000 in 1990. However, because the world car is becoming a reality and because many of its parts are being sourced in less expensive countries, the study goes on to suggest that the Canadian automotive work force could be as low as 53 000 – 60 000 in 1985 and 41 000 – 45 000 in 1990. These figures are to be contrasted with the 118 000 employed in 1978 and 98 000 in 1980.

In an effort to improve employment among the independent parts manufacturers, the federal government (urged on by the Ontario government) recently provided a series of Vehicle Duty Remission Orders in the hope of increasing manufacturing in Canada. These orders are based upon the principle that the duty on a foreign-built car is remitted to the extent that the manufacturer buys parts from Canadian parts manufacturers to be used anywhere in the world assembly operations. Unfortunately, the hoped-for increase in parts production has not taken place, except in the case of Volkswagon, which has production and assembly facilities in the United States. This is because, although the prices of Canadian parts might be competitive ex factory, the less visible additional costs, for example, duplicate tooling, testing and approval, and the shipping of parts from Canada to their place of use in Europe or Japan, more than cover the duty saved. Moreover, the process of purchasing from an alternative source in Canada creates a significant additional cost in itself. This experience does indicate, however, that the development of Honda and Nissan plants in the United States may increase Canadian independent parts production.

One other problem the Canadian industry faces is not just the decline in the number of jobs, it is the decline in the quality of those jobs. The automotive industry in Canada, based as it is on assembly, now requires only about 6 per cent skilled labour. The parts manufacturing plants require about 18 per cent skilled labour. Any in-

* Projections of future production based upon sales of the immediate past must be done with caution. The current North American market is depressed significantly by the extremely high interest rates that prevailed in 1981.

crease in the level of offshore parts imports will raise the relative importance of assembly compared to parts manufacturing. And that, presumably, would reduce the proportion of skilled labour. Furthermore, parts production is likely to become highly specialized, requiring new skills among electronic equipment technicians, those people able to service robotic and programmable electronic machinery, and programmers who will be able to develop and modify machine programs. All are currently in short supply in Canada. Community colleges have difficulty in graduating people with skills acceptable to the future demands of the industry.

A Third Generation

It is possible that a third generation of *very* fuel-efficient vehicles will be required. If so, these cars will be smaller than the subcompacts with much smaller engines. The current dilemma may then occur again. Unfortunately, it appears that the Japanese are already prepared to invade this "new" market sector, should it develop in North America. Their vehicles have two-cylinder, 0.55-litre engines, and at steady highway speeds they consume as little as 3.5 L of fuel/100 km. Three such makes are the Diahatsu Cuore, Subaru Rex and the Suzuki Alto. The price of the Suzuki Alto in Canada today, including sales tax, would be less than $3000. In contrast to the gradual and evolutionary down-sizing of the North American car, these two-seater Japanese products are rather radical. A driver may not wish to own one out of choice, but if there is an acute energy shortage, she or he may not have a choice.

A last, disquieting comment on the global production of automobiles concerns the future competitiveness of assembly and production in South Korea, Taiwan and the USSR. As yet, the lack of engineering and production quality of vehicles from these countries does not pose a threat to Canada. But after 1985, the advantages they offer – low wage rates, rapidly modernizing techniques, new plants and worker dedication – will make them a threat, not only to North America, but also to Japan.

A Better Canadian Future

The immediate future of the North American (and therefore the Canadian) auto industry will be less than brilliant. However, there are some bright spots to be found. Worldwide sales of automobiles should increase with the inevitable mid-decade demise of the older, inefficient vehicles. The expansion of the automotive industry occurred later in Canada than in Europe and the United States; so our plants are newer and our work force generally younger. Also, there is

the additional advantage of the lower value of the Canadian dollar. Unfortunately, these are just small positive aspects in the domestic industry's favour; they will not guarantee a strong future. To achieve that, we must match or exceed the productivity of the foreign competition.

As stated earlier, the Canadian auto industry consists primarily of assembly plants and independent parts manufacturers. Assembly operations are rapidly approaching total mechanization and automation. For example, General Motors has announced the introduction of 100 per cent automated inspection and online performance checking of all vehicles. Totally robotic plants are now conceivable and perhaps necessary to overcome the Japanese lead in production methods and manufacturing techniques and quality.

The independent parts manufacturers are now more important to Canada. Efficient, modern manufacturing can provide parts for the world car (or others), provided that those parts are world class. The assemblers have clearly indicated that they will be ruthless in their sourcing of parts, demanding the strictest tolerances and highest quality.

Canadian parts manufacturers must be able to supply high-technology components for a global market. If they do not, then those components will be produced inhouse by the major auto assemblers, or be obtained from Korea, Taiwan and Singapore. The ability to produce at such high standards, often in small batches, can be attained only through CAD/CAM manufacturing processes. This must be recognized. Many parts manufacturers will have no option but to pool their expertise with other manufacturers or to establish agreements with the major assemblers. Time is short; action is urgent.

Council therefore recommends that a task force be set up, by the Department of Industry, Trade and Commerce and the National Research Council, to establish a transportation CAD/CAM information, research and development centre for Canada.* The task force membership should include representatives from ITC, NRC, the transportation industry and the universities. Its mandate should include *(a)* the development of investment and R&D strategies specific to transportation, and *(b)* recommendations on necessary education programs required by these industrial sectors.

The CAD/CAM centre must take into account that such processes vary greatly by industry; for example, those appropriate for the manufacture of automobiles are not appropriate for the aerospace industry. All interested industries should be invited to participate. Included in the objectives of the centre would be the establishment of

* The centre would cover all transportation modes in Canada, not just the auto mode.

the most modern methods of quality control, whereby assembly lines do not simply allow defect detection but ensure defect prevention.

In addition, Council recommends that an Automotive Industry Action Committee be established to investigate, both nationally and internationally, possible cooperative ventures in parts design and development and related manufacturing technology. The committee membership should be drawn from the Motor Vehicle Manufacturers Association, the Automotive Parts Manufacturers Association and the United Automobile Workers, along with the appropriate government representation.

Also because the automotive industry (assemblers and parts manufacturers) is so important to the Canadian economy, its health over the next few years must be of special concern. It requires a prescription beyond the ordinary: one that will be relatively short term but yield long-term benefits; one that will enable the industry to recover and compete through the use of the latest technology; and one that can be administered immediately.

Council therefore recommends that the Automotive Industry Action Committee develop a tax-relief strategy for manufacturers to aid in the rapid depreciation of the major capital equipment.

Finally, the adversarial relationship between management and labour is no longer appropriate. Ways to improve the relationship have never been discussed in a formal manner. Since the late fall of 1981, forced cooperation, through lower wage settlements in lieu of plant closings, may have improved production, but it is unlikely to improve quality or efficiency. Discussion, involving management and labour in an educational setting, is a better process.*

Cooperative efforts must also be extended to the expertise and technology involved in building automobiles. It is essential to have a team approach that brings together machine tool builders, experts in flexible system and computer numerical control design, and large vehicle manufacturers (possibly one at a time) under the aegis of the National Research Council and one or more universities. Only then can Canada exploit any breakthrough in production techniques. The catalyst for this cooperation must be the federal government, in cooperation with the government of the province in which the industry is located.

However, a plant with worker harmony and one that is well redesigned with government commitment and support cannot simply produce more of the same. The "leap-frog" approach to technological advance is necessary. The most favourable areas for Canadian intervention are those that build on our existing expertise. We should

* There is precedence for formal educational processes: on the labour side at the Atlantic Regional Labour Education Centre (ARLEC), and on the management side at the Advanced Management Centre and the Atlantic Management Institute.

concentrate on aspects of the third-generation automobile (1-litre engine size) and on areas that involve electronic controls (we have the best software program industry in the world), our knowledge of fibre optics, and, most importantly, our knowledge of the handling, fabrication and construction of the new substitute materials from which automobiles will be built.

Council therefore recommends that the Automotive Industry Action Committee determine what role manufacturers could play in these new areas, and also determine the extent of R&D necessary to fulfil this role.

Recommendations

Auto

Cooperative ventures for auto industry

- An Automotive Industry Action Committee should be established to investigate, both nationally and internationally, possible cooperative ventures in parts design and development and related manufacturing technology. The committee membership should be drawn from the Motor Vehicle Manufacturers Association, the Automotive Parts Manufacturers Association and the United Automobile Workers, along with the appropriate government representation.

Special help required for ailing industry

- The Automotive Industry Action Committee should develop a tax-relief strategy for manufacturers to aid in the rapid depreciation of the major capital equipment.

Build on our strengths, e.g., 1-litre engine, electronic controls, fibre optics, new material technologies

- Council recommends that the Automotive Industry Action Committee determine what role manufacturers could play in these new areas, and also determine the extent of R&D necessary to fulfill this role.

All Modes

Pool our expertise to supply high-tech components for the global markets

- A task force should be set up by the Department of Industry, Trade and Commerce and the National Research Council to establish a transportation CAD/CAM information, research and development centre for Canada. The task force membership should include representatives from ITC, NRC, the transportation industry and the universities. Its mandate should include (*a*) the development of investment and R&D strategies specific to transportation, and (*b*) recommendations on necessary education programs required by these industrial sectors.

Chapter V

The Bus Mode

The Evolution of the Bus Industry

By the early 1920s, buses were an established method of intercity travel in Canada. They were run by private entrepreneurs, owning a small number of vehicles and serving only one or two routes, usually less than 80 km long. Although ridership was generally poor, particularly in rural areas, low overhead costs allowed these small companies to be viable. The advent of efficient and reliable diesel engines, coupled with an expanding road system, brought improved service. By the 1930s, buses were capable of 110 km/hr and offered options that included reclining bucket seats, air-conditioning and even air-spring suspension.

The early industry was almost completely free of regulation. However, the confusion and problems created, for example, by as many as 80 companies operating in Ontario soon led to provincial regulation. This brought about numerous bus company mergers, most of which occurred during the 1930s.

Today, the Canadian intercity bus industry is composed of 65 firms employing some 6000 persons. It provides both a passenger and a modest freight service over 62 400 route-kilometres to more than 3400 communities. The industry fleet exceeded 1900 buses in 1979 and carried 37 million passengers, slightly more than 4 per cent of the total intercity traffic.

Of the 65 carriers, 20 earn annual revenues in excess of $500 000; they account for 97 per cent of the industry's intercity revenue. Of these 20, 14 are privately owned; they earn 75 per cent of the intercity revenue, and all of them are financially viable. Nevertheless, recent declining profit trends are a major concern. The ratio of after-tax profit to operating revenue declined from 24.6 per cent in 1975 to 13.3 per cent in 1978. Furthermore, the industry's revenues are increasingly vulnerable, because they are strongly influenced by regulatory processes and mounting competition from other modes.

The major operators are now highly regionalized, with a single firm being dominant in every province except Québec and Ontario.* This pattern evolved from a regulatory environment that awarded exclusive operating authority to carriers within a given province. In exchange for this exclusivity, the carriers agreed to provide service to remote, rural communities. They were willing to accept such conditions because major intercity routes were profitable. More importantly, they were given exclusive charter, tour service and bus parcel express (BPX) rights within their region. Revenues in the industry today are consequently drawn from the profitable main intercity routes, the charter and tour services and from the BPX service, and

* Superimposed on this provincial structure is the Greyhound interprovincial network, extending from Toronto westward to Vancouver and Alaska, and the Voyageur network running eastward to the Gaspé.

then used to subsidize the required but unprofitable routes. The result is that subsidiary revenues have increased from 26 per cent of the total in 1974 to 33 per cent in 1977; meanwhile, passenger service revenues have declined from 71 per cent to 66 per cent.

The bus industry is also vulnerable to competition from other modes. The expansion of the highway system and the introduction of new buses did cause a surge in the industry in the early 1950s, but the postwar automobile quickly put an end to that growth. Ridership since the 1950s has slowly declined, interrupted only once by a brief recovery during 1976-77. This trend can be attributed, in part, to the fact that car owners think a journey in a fuel-efficient automobile is cheaper than an intercity bus ticket. If the trend continues, then revenues could erode to the point where internal subsidization of the unprofitable routes is no longer possible.

The Passenger Market and the Service Provided

Traditionally, intercity bus transportation has been aimed at low income groups, unemployed persons, housewives, students, children, senior citizens and others who do not own or drive their own automobiles. This clientele is known as the transit "captive" market, and it has sustained the intercity bus industry for the past three decades.

Inconvenient schedules and substandard terminals (often without waiting areas, washrooms or food service) are accepted by this clientele on rural and local routes. The bus companies are understandably unwilling to make improvements, because these routes have such a poor financial performance. On the high-density intercity routes, however, the standards are much higher; there are frequent departures and spacious terminals with modern amenities. These modern terminals are found in Ottawa, Montréal, Halifax, Saint John and Edmonton, but many other smaller cities, and even Toronto and Québec City, have not yet seen their terminals brought up to standard. These poor quality facilities serve as a major deterrent to auto and rail travellers contemplating a shift to the bus mode.

Reduced profits make it hard for the carriers to invest in new facilities, but it is essential that better facilities be provided, because the public image of the bus most often rests on the quality of those facilities.

Council therefore recommends that cooperative efforts be made by the bus carriers and the provincial and municipal governments to improve bus terminals in major centres where such improvements have not been made. In addition, Council recommends that Transport Canada commit funding, under the Urban Transportation Assistance Program, to modernize intercity terminals in major, regional and well-patronized rural centres.

These measures would also help the carriers broaden the nature of their clientele to include professional and business people. Already, the carriers have tried to do this by introducing "executive" bus service on routes such as Montréal – Québec City (Le Grand Express), Toronto – London (Execubus), Montréal – Ottawa (Voyageur II), Toronto – North Bay (Gray Coach Hostess Service), Toronto – Barrie (Golden Carpet Service) and the Red Arrow Service operating between Calgary, Edmonton and Fort McMurray. These deluxe operations offer, at a premium price, greater comfort and privacy, and even food and beverage service. They illustrate that a demand for this type of service exists; however, to provide the service, the number of bus seats has to be reduced from 43 or 47 to 22 or 28. This requires almost full occupancy at all times to yield a "break-even" operation. Surveys taken on these and other major intercity routes have identified severe passenger dislikes of standard equipment. More than 60 per cent of those surveyed complained of excess vibration and lack of work space, and 50 per cent complained of jolts and rough ride, noise and lack of ventilation.

To see what improvements can be made, it is necessary to assess the vehicle manufacturing side of the industry.

The Canadian Bus Manufacturing Industry

Prevost Car Incorporated of Ste. Claire, Québec, and Motor Coach Industries (MCI) of Winnipeg are the sole survivors among many Canadian long-distance-bus makers. MCI (a subsidiary of Greyhound Lines of the United States) is the larger company. Together with its US sister, it can produce more than 1300 vehicles per year. Prevost, a tour coach manufacturer, can produce only one-fifth that number. Almost a quarter of domestic production is absorbed by the Canadian fleet operators; the remainder is exported, primarily to the United States.

Small-scale production costs leave little money available for R&D by either MCI or Prevost. Unlike the foreign competition, neither of them is part of a larger automobile- and truck-producing company, so they have no readily available access to outside R&D. Also, a large number of US truck components are incorporated into all their vehicles, including engines, transmissions, brake systems, axles, suspension parts and electrical systems. Their designs are therefore severely constrained, because these components often determine the nature of the final vehicle.

In spite of these drawbacks, the Canadian-US bus market has, until recently, been secure for the domestic manufacturers – particularly MCI which has a captive customer in Greyhound. Also, the Canadian manufacturers are protected from foreign competition in

their home market by a 62 per cent importation duty.* This situation is now changing. The Canada-US bus market today is a growing one. In 1980 it absorbed approximately 1900 vehicles; the number is expected to reach more than 3000 in 1983. Foreign manufacturers have therefore been enticed into the market, and four firms of European origin† recently started to produce vehicles in the United States. There is therefore a strong incentive for the Canadian manufacturers to upgrade the designs of their buses.

This is how the Canadian product now compares with its European competition:

Ride Comfort – Canadian buses use truck beam-axle suspension systems, which produce poor ride comfort. Overseas manufacturers use independently sprung wheels all round.

Mechanical Noise and Vibration – The two-stroke diesel engine at the rear of the Canadian passenger intercity bus produces high noise (80db) and vibration levels. Overseas makes use smoother four-cycle diesel engines, which lower the interior noise level to that of luxury cars (70db).‡

Transmission Roughness – Domestically built buses, whether equiped with automatic or manually operated transmissions, suffer from jerking and shocks transmitted through the bus when gears are shifted. Overseas builders offer their customers options such as semi-automatic gear control, compounded transmission designs and oil-flow clutches.

Ventilation and Temperature – Canadian buses use only 30 per cent of the available "foregone" engine heat for vehicle interior comfort. Foreign vehicles use discreet ventilation with remotely located air inlet and outlet vents. This technology is more effective.

Seating and Amenities – The Canadian bus offers passengers fixed, closely spaced seating with little privacy and no versatility. Passengers in the rear row must endure nonreclining seats and the full discomfort of engine noise, vibration and temperature. The only amenity provided is a small washroom. European buses suffer similar restrictions, but they provide greater variety in seating arrangements.

---

* The General Agreements on Tariff and Trade (GATT) will reduce this protection by a maximum of 5 per cent per year over the next five years.

† These are Maschinenfabrik Augsburg Nürnberg, Neoplan and Vetter of Germany, and the manufacture of the Eagle, originally a Belgium design, now built under licence by Trailways Inc.

‡ Volvo B10M with Van Hool body work, measurements taken at 100 km/hr according to ISO 5128 (International Standards Organization).

Fuel Economy – Domestic intercity buses are heavier and less aerodynamic than their predecessors, so they consume more fuel. However, there is room to improve fuel economy:

i) Proven four-cycle, six-cylinder diesel engines, such as the Cummins Formula 300, consume up to 20 per cent less fuel, while producing the same power output as the two-cycle, six- and eight-cylinder engines now in use.

ii) Aerodynamic tapering at the front and rear and sloping roof ends could reduce fuel consumption by up to 20 per cent.

iii) Light-weight construction, particularly through new composite materials, could allow improvements of 4-6 per cent.

iv) Disengaging engine cooling fans at highway speeds could cut consumption by 3-5 per cent.

v) The reclaiming of waste heat from the engine exhaust manifold, oil sump and cooling fluid could provide sufficient power (through a Stirling engine) to drive summer air conditioners. Fuel consumption at that time of year would therefore improve by up to 10 per cent. Alternatively flow-through ventilation, replacing the air conditioner, could save 10 per cent of fuel consumption.

vi) Automatic speed controls on the highway could offer a 4-6 per cent fuel economy on long hauls. These devices are now available as options, following their introduction into the trucking industry.

vii) Regular preventive maintenance and more frequent vehicle servicing has been estimated to offer a 4-6 per cent fuel efficiency gain. It is the one item that operators have already begun to adopt.

The fuel conservation figures listed above are not cumulative. However, improvements in fuel economy of as much as 37-45 per cent appear possible. Since fuel costs in 1980 contributed 15-20 per cent of total operating costs, this would cut operators' overall expenditures by 4-7 per cent.

Council therefore recommends that the manufacturers assist the carriers in improving the energy efficiency of the existing bus fleets by incorporating the mechanical and body-design modifications listed above. It is further recommended that these improvements become standard features of 1985 and subsequent design-year models.

Bus Safety – There are three main areas in which bus safety in Canada could be improved.

i) Engine Placement. Under icy conditions or in heavy snow, Canadian buses are frequently withdrawn from service, because otherwise they may spin out of control. Scandinavian surveys by Volvo[1] have revealed that the rear-engine bus is almost 20 times

more likely to lose control on slippery roads than is a forward-engine bus. Also, a comparison of the performance of forward- and rear-engine buses on British and Australian roads showed that, for equal distance travelled,[2] the forward-engine bus had a lower accident rate on slippery and windswept highways than its rear-engine counterpart. Canadian intercity buses are all rear engined, because traditionally that meant lower interior noise and vibration. However, modern sound insulation and vibration isolation methods enable engines to be placed anywhere in buses. Improvements in vehicle drive-train technology* also enable central- and even forward-engine buses to match the starting traction of the rear-engine vehicles in severe snow conditions. Other tests show that forward-engine buses are more stable and less susceptible to buffeting by crosswinds. In addition, these buses, according to reports on bus accidents in the UK, Europe and Australia, offer superior crash survivability while sustaining less front end and structural collapse than their rear-engine counterparts. Finally, the disconcerting tendency of a rear-engine vehicle to swing violently on locked wheel stops, particularly on slippery roads, is greatly reduced in forward-engine designs. Canada has witnessed several severe crashes during the past 10 years involving rear-engine intercity buses.

ii) Braking Systems. Electrical or hydrodynamic retarders are energy-absorbing devices that can be used to supplement the service brakes of passenger vehicles. They have retardation capacities up to 20 times that of the diesel engine itself. Although stronger axle-gear configurations must accompany retarders, their safety benefits are multiple. The retarders reduce or eliminate the need for service brakes on long highway descents, thus preventing "fading" from overheating; this doubles the life of the service brakes while reducing their maintenance costs. A slow stop can be made safely in the event of a failure or malfunction of the service brakes. As well, vehicles experiencing a blowout of a front tire can be safely slowed by the retarder, as opposed to activating the front brakes, which could cause the bus to crash. Retarders enable a vehicle to be slowed on slippery roads more safely and more controllably, because they do not result in locked wheels. The cost of such devices is generally low and the investment can be recovered within the first year through savings in the servicing of the regular braking system. In addition, retarders are generally wear free and last the life of the vehicle. Although the use of retarders is not common in domestic bus designs, they are required by law for all European buses carrying more than 16 people, as well as by other nations.

* No-spin differentials, lockable differentials and front-wheel drive are among these improvements.

Council recommends that Transport Canada upgrade safety standards on new buses entering service. Attention must be paid to the use of retarders, brake-control systems, performance standards for tires and bus-body compressive squeeze tests.

iii) Driver Training. Mandatory defensive-driver training programs exist in some provinces for bus drivers, but they lack a comprehensive skid-control section. Provincial training centres are necessary to provide drivers with the knowledge and experience they need to operate their vehicles at higher levels of safety than is currently possible with the private training programs offered by individual operators.

Council recommends that provincial regulatory agencies operate and/or license driver-training centres. It further recommends that such agencies require bus drivers to have skid-control and defensive-driving tests, as is already done in the UK.

A Larger Bus Design

Considerable evidence exists of the need for higher-capacity, higher-comfort buses in the US and Canada. The three largest intercity carriers in Canada operate as many as 200 buses and employ some 450 drivers in the operation of second or overload buses. Numerous routes see two or three buses simultaneously duplicating schedules. Bus operators tend to publish their ridership figures by load factors, which camouflage the actual number of passengers on a given bus. For instance, a 58 per cent load factor may indicate 27 people on a 47-passenger bus, or 54 people carried by two 47-passenger buses on the same route. Such duplication can be eliminated by higher-capacity buses.

In addition, the bus traveller deserves a more comfortable vehicle that offers increased seating versatility and better onboard amenities. Such vehicles, to operate profitably, must obviously be larger than the equipment currently used. Finally larger vehicles permit the operation of cargo buses.* The need for increased baggage capacity is substantial, especially on the prairie routes, in Newfoundland and the Maritimes. Also, parcel express represents a growing market.

Design Options for Larger Buses

There are three basic designs that offer substantially more interior space than the existing 12.2-m bus. They are as follows:

a) double-decker buses;

* Referred to as "brucks" in the trade.

b) articulated buses;

c) stretched rigid-body buses with slightly higher profiles.

In the 1930s, the double-decker bus saw intercity use by Greyhound in the southwestern United States and from 1950 into the 1970s, it was used in the United Kingdom on the London-Blackpool and several other routes. Highway double-decker operations ceased in the UK after several overturn accidents raised questions in the British House of Commons regarding the safety of such buses. Operator acceptance of double-decker intercity buses appears to be relatively low in Canada; their application is now restricted to the Vancouver and Victoria areas.

The articulated bus, a common urban vehicle, has not been widely used on intercity roads; its operator acceptance is also very low. These vehicles are expensive and still being developed. To be viable, they will need to be built in lengths of more than 23 m. Tests in Calgary and Edmonton with city transit articulated buses indicate that, despite the use of active anti-jackknife controls, they often jacknife on snowbound roads.* The sheer complexity of these buses also detracts from their appeal, as does the loss of space in the articulation joint (although this space can be used as a coat rack).

The third option is to lengthen the existing rigid-bus structure, and to increase its height by approximately 45 cm and its width by 15 cm (the legal limit). Lengthened rigid buses beyond 12.2 m have been successfully introduced in Sweden and Switzerland. Such vehicles, built domestically, would be able to offer parts compatibility with existing buses.

This study conducted an analysis, which illustrated that the rigid design with increased height was the most attractive option. Designs from 13.7 m to 18.5 m were examined in terms of existing regulations, operational stability, seating and luggage capacities, relative operating costs, and relative revenues through increased capacity. A productivity gain was calculated based on the latter two items and the initial capital outlay. A brief summary of the analysis is shown in Table V.1, and a schematic view of the vehicles is presented in Figure V.1.[3] The marked advantages of larger rigid buses show up clearly. Table V.1 shows that, despite increased initial capital costs, the additional seating and baggage capacity allows revenues to increase more rapidly than operational expenses. The 15.8 m model gives an overall productivity gain of at least 10 per cent. For executive coach configurations, the 18.5-m design gives a pro-

* Ontario Ministry of Transport tested jackknife-control devices for articulated vehicles in 1980. Not all jackknife-control devices prevent jackknifing. See Report CVOS-TR-80-03. GMC, on its 17-m and 18.5-m RTS "mega" articulated buses, uses antilock brakes to reduce jackknifing caused by braking. Jackknifes do occur without the use of brakes.

Table V.1 – Comparison of Expanded and Conventional Buses

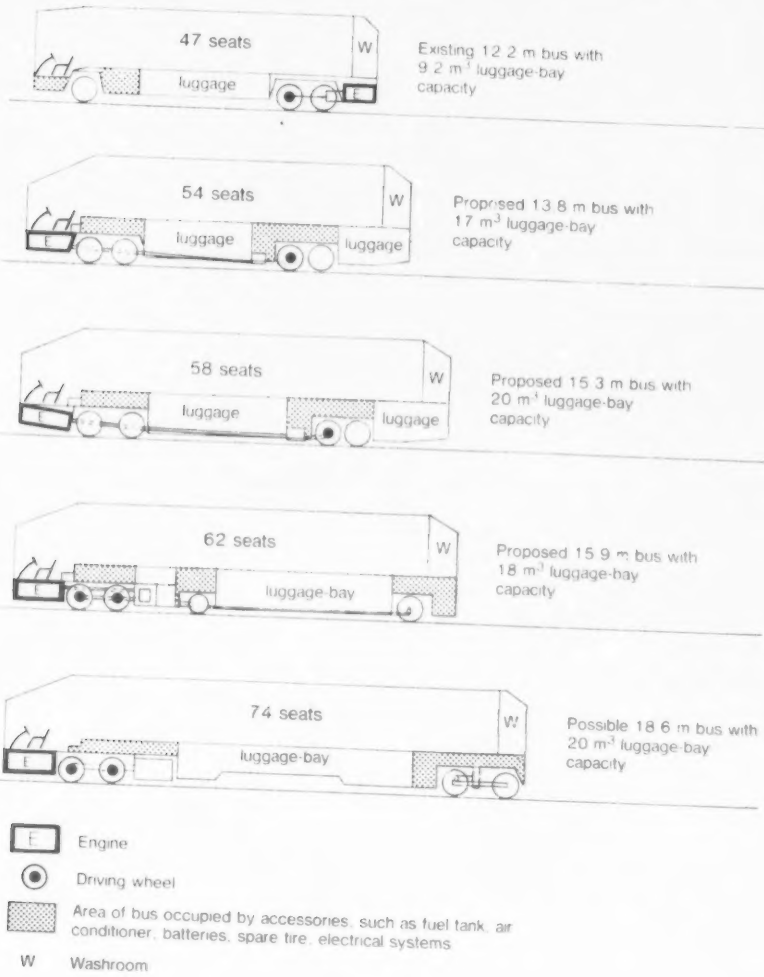
	Rigid Buses					Articulated Bus	
	12.1-m	15.8-m	percentage increase	18.5-m	percentage increase	18.2-m	percentage increase
Costs x 10^4 (1982$)	190	235	25	285	50	400	110
Capacities							
Passengers							
813 mm pitch*	51	67	31	79	55	67	31
864 mm pitch	47	63	34	75	60	63	34
914 mm pitch	43	59	37	71	65	59	37
Executive	24 29	40 44	50	54 60	111	40 44	58
Baggage (m^3)							
Standard	9.20	11.87	54	11.87	54	9.91	7
High-level	15.57	18.13	115	19.8	115	14.15	–10
Mechanical							
Number of axles	3	4		4		3 4 5	
Power (kW)‡	210	250		295		250	
GVW x 1000 kg§	17 18	20 22		22 24		21 23	
Relative costs							
Fuel oil	100	115		120		120	
Tires	100	125	20	150	30	160	60
Maintenance	100	120		130		170	
Relative Productivity‖							
Low	100	110		116		105	
High	100	115	15	125	25	110	10
Manoeuvring (m) (90° turn)							
Outer radius	14.48	14 48		14.48		12 8	
Inner radius	8.4	8.4		6.4		6.4	
Tailswing	0.4	0.6		0.6		1.2	

* Distance between seat centres.
‡ Height: Standard bus is 3.3 m high, whereas high-level buses are 3.8 m high
‡ 1 kW = 1.345 hp.
§ GVW refers to Gross Vehicle Weight.
‖ Based on (revenue km) (operating cost km) ratios, or output input.
Note: An 18.2-m-articulated bus loses approximately 2.3 m of revenue-earning space in the articulation joint.

ductivity gain of more than 20 per cent. The 18.2-m articulated bus is also compared, showing its productivity gain to be less than 10 per cent.

The increased capacity of larger designs can also provide the space for many amenities. These can include kitchenettes, food and beverage dispensing, slumber bays, private compartments, berths or roomettes, partitioned lounge or smoking areas, improved seating versatility (such as face-to-face or three rows of single seats and two isles for increased privacy), larger and additional washroom facilities, magazine book racks, and onboard telephone service. With

Figure V.1 – Comparison of Existing and Lengthened Buses



amenities such as these, the range of comfortable bus travel can increase from its current maximum of 500 kilometres to 800 kilometres per day.

Size and Manoeuvrability Considerations

Both ends of an intercity journey take place within the urban environment. The streets are narrower, the turns much tighter and the

traffic more congested than anything encountered on the open highway. It is thus mandatory that the larger vehicle have acceptable manoeuvrability, preferably equal to that of the existing 12.2-m buses. This guarantees safety in the urban areas and prevents the public rejection of vehicles that would further impede city traffic. Fortunately, manoeuvrability can be maintained through the progressive incorporation of design features.

Such features include tapering of the body, a tighter front-wheel turning angle* and steerable rear axles. A 13.7-m bus can turn within the same envelope as the existing 12.2-m bus, when the nose and tail sections are tapered slightly. In 1978 Volvo of Sweden developed a steering system enabling cut angles of 55 degrees compared to the 42 degrees now used in Canada. The higher front-wheel turn angle allows an extension up to 15.3 m. The introduction of rear wheels that are independently steerable permits a 15.9-m bus to negotiate within the same outer and inner radius, and with the same degree of tail swing, as the 12.2-m bus. Designs of greater length, although turning within the same outer perimeter, require a smaller inner turning radius.

Today, all provincial Department of Transport regulations allow the use of 18.3-m tractor semitrailer trucks, which turn on the same radii as the 15.3-m bus shown in Figure V.2, or as an 18.5-m bus with self-steering rear wheels. Also, all steering components to build these longer vehicles are available from Canadian supplier/manufacturers.* To further ensure safety, rigid buses using steerable rear wheels may be operated with front-wheel drive and hydraulic front-steering control. In 1981, NRC tested a steerable rear-axle system built by ASTL[4] on a 24.5-m semitrailer towed by a tractor truck. The independently steerable rear wheels enabled this behemoth to negotiate curves in no more road space than existing vehicles.

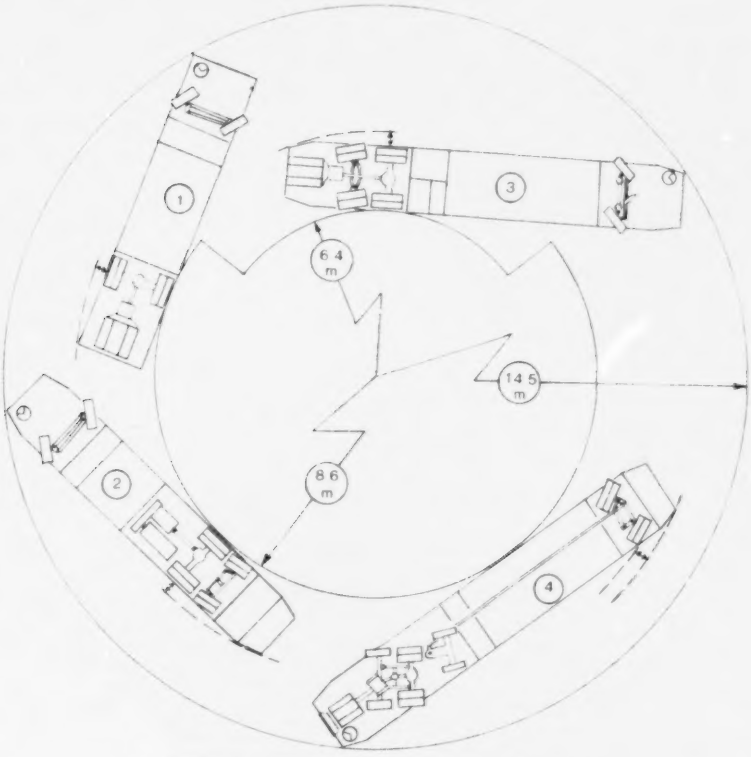
Council recommends that the Canadian Conference of Motor Transport Administrators review the suggested options for intercity bus designs and request, of provincial regulatory boards, length and manoeuvrability standards that will allow larger rigid buses to operate on highways and city streets.

Industrial Opportunities

As indicated above, competition for Canadian bus manufacturers is increasing in the United States (where nearly 75 per cent of output is sold). In overseas markets, MCI has made some inroads into Austral-

* Components to develop these systems are made in Canada.
* For example, Auto Steering Trailers Limited, Toronto (ASTL).

Figure V.2 – Turn Circle Comparison of Existing and Proposed Buses



1. Existing 12.2 m bus: 47 seats and 10.2 m^3 baggage bay
2. Proposed 13.8 m bus: 54 seats and 10.2 m^3 baggage bay
3. Proposed 15.3 m bus: 58 seats and 12 m^3 baggage bay
4. Proposed 16 m bus: 62 seats and 12 m^3 baggage bay (hydraulic front steering)

ia, South Africa, Taiwan and Saudi Arabia,† and Prevost has made inroads into Tunisia. However, recent competition from Denning,‡ Hino, and Mitsubishi have cut short the sale of MCI products in the Australian market, and the heavy representation of European, British and Japanese truck and bus manufacturers in South Africa make that market uncertain, too.

What then is the future for our domestic manufacturers both in North America and abroad? Is the manner in which we now make

† Sale of 200 buses made to a Greyhound subsidiary operating in Saudi Arabia.
‡ Domestic Australian builder.

buses globally competitive? To be assured of an affirmative answer, we must solve problems associated with the source of supply of major parts, the introduction of new techniques and the ability and willingness to adapt and adopt new technology.

Current assembly procedures mean that 40 per cent of the net weight of vehicles made in Canada is provided by parts purchased from foreign (US) manufacturers. In contrast, bus builders in Europe and Japan purchase less than 10 per cent of the vehicle weight elsewhere. They are able to produce components in their own plants, as well as build automobiles, trucks and buses. Their buses are also exported into distant markets in kit forms, to enable assembly in the market country.

Canadian builders use techniques involving the cutting, bending and welding of metal; they also use machine processing, including boring, reaming, drilling and thread-cutting operations during manufacture. Joining processes include riveting the body panels, welding the chassis and bolting accessories. Numerical control machinery is used only in some machining, cutting and metal-removal processes. Again, by comparison, foreign builders use extensively automated riveting techniques, robot-controlled welding, computer-directed lathes, and automated stamping and forging procedures. Computer-aided design and computer-aided manfacturing (CAD/CAM) has not had a noticeable impact on domestic bus production; nor has robotics. However, composite materials are now being introduced to North American buses by Greyhound, and they are being used in urban bus designs.

The preservation of our current share of the world market may not be ensured unless more attractive and comfortable vehicles with a greater range of options and flexibility are offered to the operators. In other words, superior vehicles produced by superior methods will be necessary. New techniques and materials must be introduced, at least at the same rate as those by the foreign competition. Three factors have delayed this. One is the import duty, which, while protecting the manufacturer, has until recently discouraged Canadian carriers from bringing in a small number of vehicles for testing in the Canadian environment. The second is the presence of a captive and protected market, which has tended to stifle design improvements and cut off funding for R&D and new production technology. Thirdly, inflexible legislative practices have also stifled design changes. Foreign competitors, in contrast, have often received substantial support from their governments, including flexibility in legislation that allows for the testing and operation of diverse bus designs.

Council therefore recommends that the domestic bus manufacturers, the Department of Industry, Trade and Commerce and the appropriate provincial governments determine the most efficient process leading to the design and manufacture of larger rigid buses,

and that the domestic bus manufacturers, after extensive marketing consultation with the carriers, then design and develop such buses.

One final comment on the export market. Domestic builders may wish to market their vehicles abroad through truck and bus builders that are already well established in the overseas markets. An established trade name is likely to be better received by foreign buyers in the first year than one that is unknown.

Recommendations

Bus

Better facilities essential

• Cooperative efforts should be made by the bus carriers and the provincial and municipal governments to improve bus terminals in major centres where such improvements have not been made. In addition, Council recommends that Transport Canada commit funding, under the Urban Transportation Assistance Program, to modernize intercity terminals in major, regional and well-patronized rural centres.

Funds for modern terminals

Design modifications for fuel savings

• Bus manufacturers should assist the carriers in improving the energy efficiency of the existing bus fleets by incorporating mechanical and body design modifications. It is further recommended that these improvements become standard features of the 1985 and subsequent design-year models.

Safety equipment

• Transport Canada should upgrade safety standards on new buses entering service. Attention must be paid to the use of retarders, brake-control systems, performance standards for tires and bus-body compressive squeeze tests.

Driver training

• Provincial regulatory agencies should operate and or license driver-training centres. Council further recommends that such agencies require bus drivers to have skid-control and defensive driving tests.

Review of standards needed

• The Canadian Conference of Motor Transport Administrators should review the suggested options for intercity bus designs and request, of provincial regulatory boards, length and manoeuvrability standards that will allow larger rigid buses to operate on highways and city streets.

Preserve our share of the world market

• Council therefore recommends that the domestic bus manufacturers, the Department of Industry, Trade and Commerce and the appropriate provincial governments determine the most efficient process leading to the design and manufacture of larger rigid buses, and that the domestic bus manufacturers, after extensive marketing consultation with the carriers, then design and develop such buses.

Appendices

Appendix 1 – Opportunities in Canadian Transportation – Study Documents

I. Conference Proceedings

Opportunities in Canadian Transportation:

1. *Intercity Passenger*, Ottawa, 17-18 May 1979
2. *Auto as a Mode/Industry*, Toronto, 4-5 October 1979
3. *Bus/Rail as Modes, as Industries*, Montréal, 25-26 October 1979
4. *Air as a Mode/Industry*, Edmonton, 29-30 November 1979
5. *Intercity Passenger*, Ottawa, 21-22 May 1980

II. Working Papers

1. N.B. MacDonald, "Canadian Automobile Industry: Some Emerging Perceptions/Prescriptions," March 1980.
2. N.B. MacDonald, "The Future of the Canadian Automotive Industry in the Context of the North American Industry," November 1980.
3. Ata M. Khan, "Transportation Energy Utilization," November 1980.
4. Ata M. Khan, "Railway Electrification: Energy Implications," November 1980.
5. Ata M. Khan, "VIA Rail Canada, An Analysis of VIA's Potential in Fulfilling Rail Passenger Policy Objectives," November 1980.
6. H. Valentine, "Passenger Rail Equipment Options for Canada," August 1982.
7. H. Valentine, "Intercity Bus in Canada: An Industry at its Turning Point," forthcoming.

III. Internal Study Papers

1. J. Lukasiewicz, "Intercity Transportation of Passengers in Canada: Opportunities for Rationalization and Modernization," 1978.
2. M. Swinton, "The Toronto International Airport: Adapting its Planning to a New Order of Constraints," 1978.
3. Fred Rimrott, "The Groundside Airport Access Problems in Montréal and Toronto," 1978.
4. S. Gelman, "Railway Relocation in Canada's Urban Centres," 1978.

5. Ata M. Khan, "Railway Electrification: R&D and Industrial Opportunities," March 1981.
6. John H. Nasser, "CAD/CAM Technology in Canadian Aerospace Industries," June 1981.
7. Douglas Smith, "The Case for the Development of a Bi-level, Self-propelled Rail Car," 1982.

IV. Additional Reading

1. Canadian Transport Commission, *Annual Report*, Ottawa, 1972 through 1981.
2. J. Lukasiewicz, *The Railway Game*, McClelland and Stewart Limited, Toronto, 1976.
3. Jack M. Nilles, F. Roy Carlson Jr, Paul Gray and Gerhard J. Hanneman, *The Telecommunications-Transportation Tradeoff: Options for Tomorrow*, John Wiley & Sons, New York, 1976.
4. Transport Canada, *Montréal/Québec City Survey of Voyageur Bus Travellers*, Report TP 1486, May 1978.
5. Peter H. Aykroyd, "Review of Transportation R&D Activity in the Federal Government," Canadian Transportation Research Forum, Winnipeg, Manitoba, 12-14 June 1978.
6. Ontario Ministry of Transportation and Communications, *Tests of Self-Steering Trailer Axles*, Report CVOS-TR-79-02, May 1979.
7. J. Lukasiewicz, "Public Policy and Technology: Passenger Rail in Canada as an Issue in Modernization," *Canadian Public Policy*, vol. 4, Autumn 1979, p. 518.
8. Jack Patriarche, *Transportation Jurisdiction in Canada*, Council on Transportation Policy of the Roads and Transportation Association of Canada, September 1979.
9. N.D. Whitehouse and D.E. Winterbone, "The Internal Combustion Engine and its Future," *Endeavour*, New Series, vol. 5, no. 1, 1980, p. 29.
10. P. Beardmore, J.J. Harwood, K.R. Kinsman and R.E. Robertson, "Fiber-Reinforced Composites: Engineered Structural Materials," *Science*, vol. 208, May 1980, p. 833.
11. Ontario Ministry of Transportation and Communication, *Performance Evaluation of Several Jackknife-Control Devices*, Report CVOS-TR-80-03, June 1980.
12. Ralph E. Cross Sr, "The Future of Automotive Manufacturing: Evolution or Revolution?" *Automotive Engineering*, vol. 88, no. 7, July 1980.

13. R.A. Grimm, R.J. Bremer and S.P. Stonestreet, "GM expands C-4 System Use," *Automotive Engineering*, vol. 88, no. 8, August 1980, p. 33.
14. W.A. Rodgers, D.R. Kimberlin and R.A. Mead, "Multiplexing Simplifies and Expands Driver Controls," *Automotive Engineering*, vol. 88, no. 8, August 1980, p. 50.
15. W.L. Walters, "Electronic Emission Control Diagnoses its Own Problems," *Automotive Engineering*, vol. 88, no. 8, August 1980, p. 43.
16. Ray Barton, "Intercity Highway Traffic Volume Changes and Intermodal Comparisons 1972-78," Roads and Transportation Association of Canada, Toronto, 29 September-2 October 1980.
17. D.R. Perley and S. Gelman, "Modified Conventional Takeoff and Landing Operations for Mainline Service," Fifth Annual FAA Aviation Forecasting Conference, Silver Springs, Maryland, 23 October 1980.
18. Mark C. Baetz, "Formal Consultative Industrial Planning Involving Industry, Government and Labour in Canada: The Tier I/Tier II Approach," Wilfrid Laurier University, Research Paper Series No. 3081.
19. Hans J. Bocker and Herman O. Overgaard, "Quality Circles: An Answer to the Productivity Challenge," Wilfrid Laurier University, Research Paper Series No. 3281.
20. Hans J. Bocker and Herman O. Overgaard, "Quality Circles: A Managerial Response to the Productivity Problem," Wilfrid Laurier University, Research Paper Series No. 3381.
21. C.H. Glenn, "Energy for Air Transport in the 1980s," Annual Conference of the Canadian Institute of Traffic and Transportation, Vancouver, BC, 23 January 1981.
22. R.J. Brodd, "New Battery Technology for Electric Vehicles," *Electric Vehicle News*, February 1981, p. 4.
23. C.H. Glenn, "The Case for the Small Jet Transport," Air Industry Association Conference, April 1981.
24. J. Joss, "The Wright Stuff," *Science 81*, April 1981, p. 54.
25. Ata M. Khan and S. Gelman, "Opportunities for Improved Co-ordination Between Rail and Other Passenger Modes," Sixth Annual Conference of the Institute of Transportation Engineers, Vancouver, BC, 22-24 April 1981.
26. Peter J. Mullins, "Europe's Component Makers: A Rough Road Ahead," *Automotive Industries*, May 1981, p. 49.
27. H. Whittington, "The Wing's The Thing," *Canadian Aviation*, June 1981, p. 57.
28. John H.F. Woodroffe, *A Performance Evaluation of a Long Load Steering Axle Dolly on the Alaska Highway*, National Research Council of Canada, Ottawa, July 1981.

Appendix 2 – Other Science Council Publications Touching on Transportation

Report 4,
Towards a National Science Policy for Canada,
October 1968.

Report 11,
A Canadian STOL Air Transport System: A Major Program,
December 1970.

Report 23,
Canada's Energy Opportunities,
March 1975.

Report 27,
Canada as a Conserver Society: Resource Uncertainties and the Need for New Technologies,
September 1977.

Background Study 12,
Aeronautics: Highway to the Future,
J.J. Green, 1970.

Background Study 17,
A Survey of Canadian Activity in Transportation R&D,
C.B. Lewis, May 1971.

Background Study 33,
Energy Conservation,
F.H Knelman, July 1975.

Background Study 43,
The Weakest Link: A Technological Perspective on Canadian Industrial Underdevelopment,
J.N.H. Britton and J.M. Gilmour, October 1978.

Statement of the Vice-Chairman,
The Canada-US Auto Pact: A Technological Perspective,
J.J. Shepherd, 1978.

Notes

I. Intercity Passenger Transportation: Growth to a Multimodal System

1. Transport Canada, *Passenger and Goods Transportation – an International Comparison 1960-77*, Report TP 3039, May 1981.

2. Statistics Canada Travel Survey sponsored by the Canadian Government Office of Tourism and the federal Department of Transport, as reported in the *Globe and Mail*, Toronto, 6 August 1981. In 1981, domestic air travel in the US declined 3.9 per cent. American Transportation Association, Washington, DC, March 1981.

II. The Air Mode

1. A recent comprehensive discussion on the operational aspects of safety in the air mode is contained in, Canada, Commission of Inquiry on Aviation Safety, Mr. Justice Charles Dubin, *The Dubin Report*, Ottawa, 1981, 1982.

2. Approximately two dozen companies were involved: the detailed results of this analysis are to be found in the internal study paper by John Nasser, "CAD/CAM Technology in Canadian Aerospace Industries," June 1981.

3. Information on the US Air Force ICAM Project was published in "Doing Business with the US Air Force," *R&D Bulletin*, Department of Supply and Services, May 1981, pp. 2-4.

III. The Rail Mode

1. Department of Supply and Services, *Economic and Financial Analysis of the Corridor Rail Passenger System*, R.D. Partridge, Report No. 40-79-03, Ottawa, 1979.

2. Canadian Transport Commission, *Annual Report*, Ottawa, 1973 through 1981.

3. John M. Day, *The Transcontinental Passenger Train in Western Canada*, Report for Alberta Economic Development, Transportation Services, 1981.

4. DSS, *Economic and Financial Analysis of the Corridor Rail Passenger System, op. cit.*

5. See H. Valentine, "Passenger Rail Equipment Options for Canada," Working Paper No. 6, Ottawa, August 1982.

IV. The Auto Mode

1. N.B. MacDonald, "Canadian Automobile Industry: Some Emerging Perceptions/Prescriptions," Working Paper No. 1, Ottawa, March 1980; N.B. MacDonald, "The Future of the Canadian Automotive Industry in the Context of the North American Industry," Working Paper No. 2, Ottawa, November 1980; N.B. MacDonald, *The Medium-Term Employment Outlook: Canadian Automotive Industry*, Task Force on Labour Market Development, Technical Study No. 21, July 1981.

2. N.B. MacDonald, Working Papers 1 and 2, *op. cit.*; W.J. Abernathy, K.B. Clark, Alan M. Kantrow, "The New Industrial Competition," *Harvard Business Review*, September-October 1981; United States Department of Transportation, *The Goldshmidt Report: The US Automobile Industry 1980*, Washington, DC, 1980.

3. The Chairman of General Motors, H.B. Smith, has stated that absenteeism is costing the US industry over $1 billion per year. Address to the National Press Club in Washington, DC, 13 January 1981.

4. Abernathy, Clark and Kantrow, *op. cit.*

5. N.B. MacDonald, Technical Study No. 21, *op. cit.*

V. The Bus Mode

1. *Bus and Truck Transportation*, Perth, Australia, February 1981, pp. 27-28.

2. Institute of Mechanical Engineers, *Proceedings of the Symposium on Passenger Commercial Vehicles*, London, England, 1975.

3. A comprehensive summary of the research findings is laid out in, H. Valentine, "Intercity Bus in Canada: An Industry at its Turning Point," forthcoming.

4. See "New Self-Steering Axels Tested," *Canadian Transportation and Distribution Management*, Toronto, Ontario, September 1981, p. 43.

Index

Abernathy and others of Harvard, study by, 66
Accident rate:
 on buses, 80-81
 on airlines, 20
Advanced Management Centre, 71*n*
Aerospace industry, 30-41
Air Board Act of 1919, 18
Air Canada, 18, 19, 26
Air mode, 18-35:
 characteristics of, 8
 Competition in, 18-19
 deregulation of, 15, 24
 and government policy, 18-19
 and nonstop flights, 24
 and the oil crisis, 20-23
Aircraft:
 costs, 26-27
 small fuel-efficient, 26-29
Aircraft industry, light, future in Canada, 29
Aircraft types, 22, 26, 27, 32, 58*n*. See also STOL
Airlines:
 characteristics of users of, 20
 charter, 18, 25
 comparison of, 19-20
 fares, 20
 financial performance of, 20-22
 income from nonflight and nonoperational activities, 21
 licensing regulations for, 24
 local, 18, 19-20
 methods of increasing productivity of, 22-23
 national, 18, 19
 regional, 18, 19, 22
 reliability of, 20
 and rising fares, 22-23
 and safety, 20
Airports:
 optimal use of, 23
 small, 11, 25
Amtrak, 42
Atlantic Management Institute, 71*n*
Atlantic Regional Labour Education Centre (ARLEC), 71*n*
Australia, 86
Auto fleet, 59-60
Auto industry, 61-63:
 and automated assembly plants, 70
 and competition from Japan, 65-67
 creative functions imported for, 62
 decline of, 58-59
 employment in, 62, 68-69
 its immediate future, 69-72
 in Japan, *see* Japan, auto industry in
 losses of, in North America, 58
 nature of, in Canada, 69
 production in, 59, 71
 tax relief for, 71
Auto manufacturers, tax relief for, 71
Auto mode, 56-73:
 characteristics of, 7-8
 dominance of, 56
 and the environment, 56
 growth since 1974, 57-58
 "perceived" cost of, 8, 42, 58
 "replacement cycle," 59
 use of fuel, 57-58
Auto Pact (Canada-US Automotive Production Trade Agreement of 1965), 61-63, 64-65
Auto parts, 71:
 importation under Auto Pact, 64
Auto parts industry, 64:
 and CAD/CAM, 70
 employment in, 68
 and need for skilled labour, 69
 and Vehicle Remission Orders, 68
 and the world car, 70
Auto quality, 56-57
Auto Steering Trailers Limited (ASTL), 86
Automation:
 in aerospace industry, 31, 33
 in auto industry, 61, 70
 in bus manufacture, 88
 See also CAD/CAM
Automobiles:
 changes in, 59-61
 electric, 14, 61
 four-cylinder, 60, 64
 fuel-economy of, 57, 58, 65
 fuels for, 60
 imported (mainly Japanese), 57, 58, 60, 61, 65-67, 68
 prices of, 63, 65*t*
 quality of, 65
 three cylinder, 60, 60*n*
 two-cylinder, 69
 very fuel-efficient, 69, 72
 weight of, 61
Automotive Industry Action Committee, 71, 72
Automotive Parts Manufacturers Association, 71
Aviation, private, 29

Bell Labs, 15*n*
Brazil, as engine manufacturer, 65
Bus companies, 76, 77, 78, 82
Bus designs, and legislation, 88
Bus features:
 braking systems, 81, 83*n*

automatic speed controls, 80
comfort, 79
engine placement, 80-81
fuel consumption, 79, 80
light-weight construction, 80
noise and vibration, 79
retarders, 81
safety, 80-82, 86
seating, 79
steering, 85, 86
tapered body, 80, 86
transmission roughness, 79
turning angles, 85, 86, 87*f*
ventilation, 79
Bus industry, 86-88:
intercity, *see* Bus mode
Bus manufacturers, 78-82:
foreign, 79, 86-88
opportunities for, 86-89
and requirement for new techniques and materials, 88
Bus mode, 76-90:
accident rate in, 80-81
characteristics of, 8
competition from other modes, 77
financial state of, 76-77
passenger market, 77-78
productivity gain with new designs in, 83-85
quality of service in, 77-78
Bus parcel express, 82
Bus parts, 87
Bus service, "executive," 78
Bus terminals, 77
Bus types:
articulated, 83-86, 87*f*
Canadian versus European, 79
cargo, 82
conventional versus expanded, 83, 84*t*
double decker, 82
stretched rigid-body, 82, 83, 84-86, 87*f*, 88

Calgary, 83
Canada-US Automotive Production Trade Agreement of 1965, *see* Auto Pact
Canadian Air Transportation Administration (CATA), 25
Canadian Conference of Motor Transport Administrators, 86
Canadian National (CN), 11, 38, 40, 43, 51
Canadian Pacific Air, 18, 19, 26
Canadian Pacific (CP), 38, 40, 43, 51
Canadian Transport Commission (CTC), 11, 12, 25, 38, 43, 48*t*, 51
Canadian Transportation Act, 12
Carriers, levels 1, 2, and 3, *see* Airlines: national, regional *and* local
Chrysler, 62
Composite materials, 32-33:
in aircraft manufacture, 31-33
in auto production, 61, 72
in bus manufacture, 80, 88
Computer-aided design/computer-aided manufacturing (CAD/CAM):
in aerospace firms, 30-31, 33
in auto parts industry, 70
in bus manufacture, 88
information, research and development centre, for transportation, 70
Computer-Aided Manufacturing International (CAM-I),31
Costs:
of air travel, 8, 26, 27
and auto mode, 8, 63, 65-66
of bus travel, 8, 77
of transportation system, 11
and rail mode, 8, 40-41, 43-44, 46*n*, 49*t*, 50, 51, 52*f*
Crown corporations, 11, 12, 24

Daimler Benz, 60*n*
DeHavilland Aircraft of Canada, 28
Denning, 86
Department of Industry, Trade and Commerce, 29, 32, 34, 50, 70, 88
Department of Transport, 18
Deregulation of air mode, 15, 24
Diahatsu Cuore, 69
Driver training, and buses, 81-82
Duplication of service, 7, 39

Eastern Provincial Airways, 18, 19*n*
Economic importance of transportation, 6
Edmonton, 83
Education:
for transportation industry, 70
for aerospace industry, 34
for auto parts industry, 69
Electricity:
in cars, 14, 61
in trains, 14, 45*n*
in transportation, 14
Electronic controls:
in air mode, 25
in auto industry, 72
Employment:
in auto industry, 63, 67-69
in bus mode, 76
in aerospace industry, 33, 34
in transportation, 6
Energy:
and choice of travel mode, 7
and new fuels, 13-14
Energy conservation, 59, 69
Energy crisis of 1974, 58
Energy efficiency of buses, 80

Energy shortage, 57
Engines, aircraft:
  General Electric Snecma Cfm56, 22
  high-bypass-ratio, 22, 28
  multi-stream, 28
  Pratt and Whitney, 22
  Rolls-Royce RB419 turob-fan, 28
Engines, bus, four-cycle six-cylinder diesel, 79
Engines, automobile, 60-61. *See also* Automobiles, two-, three- and four-cylinder
Engines, train, 45*n*, 47*f*
Engine placement, on buses, 80-81
England, 64*n*
Enterprise Development Programs, 33
Exports:
  of aerospace products, 34
  of buses, 89

Federal government, 25, 71
Fibre-reinforced plastics (FRP). *See* Composite materials
Fibre optics, 72
Ford, 62, 64*n*
Fuel:
  alcohol as, for cars, 60
  aviation, cost of, 20, 21, 22-23, 23*n*
  and buses, 80
  consumption in automobiles, 67
  diesel, for cars, 60
  hydrogen as, 23, 60*n*
  lead-free, 56
  new, 13-14
Fuel-efficiency of autos, 58, 59-60, 69, 72

General Agreements on Tarrif and Trade (GATT), 79*n*
General Motors, 60, 62, 64*n*, 70
General Motors Canada, 62
German automobiles, 58
Goldshmidt, study by, 66
Greyhound, 76*n*, 78, 83, 87*n*, 88

Hino, 87
Honda, 68

Imports:
  of auto parts, 64
  of buses, 79, 88
  See also Automobiles, imported
Inflation, 14, 20, 43, 44
Instrument-landing systems (ILS), 25
Investment strategies for transportation, 70
Isuzu Motors, 60*n*
Italy, 64*n*

Jackknifing, 83, 83*n*
Japan:
  auto industry in, 59, 64*n*, 65-67
  train service in, 41
  and very fuel-efficient automobiles, 69
Japanese imports, *see* Automobiles, imported
Jikoda, 66*n*

Korea, source of auto parts, 70
Kyoto Ceramics, 60*n*

Labour management relations in auto industry, 71

Maschinenfabrik Augsburg Nürnberg, 79*n*
Mexico, 64*n*
Microprocessors, in automobiles, 60
Mitsubishi, 87
Modal attributes, 7-8
Motor Coach Industries (MCI), 78, 86
Motor Vehicle Manufacturers Association, 71

"Nader movement," 56
National Research Council (NRC), 29, 32, 33, 70, 71, 86
National Transportation Act (NTA), 11
Neoplan, 79*n*
Nissan, 68
Nonstop flights, need for, 24
Nordair, 18
Numerically controlled (NC) machines, 30, 31, 88

Ontario government, 68
Ontario Ministry of Transport, 83*n*
OPEC (Organization of Petroleum-Exporting Countries), 57

Pacific Western Airlines, 18, 19
Prevost Car Incorporated, 78, 87
Problems of the transportation system, 11-15
Provincial governments, 11, 33, 88:
  responsibility for transportation, 11
  role in auto manufacturing, 71

Quality rating of imports and North American cars, 66, 67*t*
Quality control in auto industry, 66, 71
Québec Air, 18

Rail equipment:
ACE 3000 locomotive, 45*n*
Bilevel rail car (BRC), 45-51
brakeman's coach, 46, 48*t*, 50
Light Rapid Comfortable (LRC) trains, 39, 48*t*
locomotive-hauled consists, 40-41, 45, 48, 49*t*, 50, 51
magnetically levitated trains or Maglevs, 45*n*
powered BCR (PBCR), 45, 46, 47*f*, 48*t*, 50
rail diesel car (RDC), 41, 45-51
railbuses, 48*t*
revenue car, 41*n*
Tempo cars, 40
Turbos, 40, 48*t*
Rail lines, electrification of, 14, 45*n*
Rail mode, 38-53:
characteristics of, 8
deterioration of, 15, 38, 39-40
new equipment required for, 45-53
and steam power, 45
Rail passenger policy, 39
Rail services:
corridor, 38, 39, 41, 44, 48*t*
regional, 38, 41, 43, 44, 48*t*
remote, 38, 43, 44, 48*t*
transcontinental, 39, 41, 43, 44-45, 48
Railway Act, 38, 43
Railways, financial state of, 39
Railway Transportation Comprehensive Audit, 52
R&D:
in aerospace industry, 30, 32, 33-34
in auto industry, 62-63, 72
in bus manufacturing, 78, 88
on composites, 32
on new railway vehicles, 50
on strategies for transportation, 70
Regulation of transportation, 11-12
Robotic factories:
for automobiles, 70
for buses, 88

Safety:
of airlines, 20
of autos, 11
of buses, 80-83
Saudi Arabia, 87
Sheet-metal fabrication, 30-31
Shinkansen, 41*n*
Singapore, 70
Society of Automotive Engineers (SAE), 62
South Africa, 87
South Korea, 69
Standing Committee on Rail Passenger Transportation, 52
Statistics Canada, 34
STOL (short take-off and landing) aircraft, 27-29
STOL jet aircraft, 27, 33:
R&D on, 28, 29
market analysis required for, 29
Subaru Rex, 69
Subsidies, 10-11:
to aerospace industry, 33
to airlines, 21
to passenger trains, 10, 11, 38, 39, 40, 43
Subsidization, internal, of bus routes, 76-77
Suzuki Alto, 69
Sweden, 83
Switzerland, 83

Taiwan, 69, 70, 87
Task force, to establish transportation CAD/CAM information, research and development centre, 70
Task Force on Airport Management, recommendation of, 25
Task Force on Labour Market Development, study by, 68
Tax relief for auto manufacturers, 71
Technical Advisory Committee on Composites, 32
Telecommunications, their possible impact on travel, 15
Third-generation autos, *see* automobiles, very fuel-efficient
Trans-Canada Airlines, 18
Trans-Canada Highway, 11
Transport Canada, 11, 12, 24, 25, 29, 43, 50, 51, 77, 81
Transportation policy, 24-25
Transportation Price Index, 6
Travel, discretionary and required, 7, 25

Unions and VIA Rail, 43-44, 50, 51
United Automobile Workers, 71
United Kingdom, 83
United States, 57, 59, 78:
and Canada's auto industry, 62-65
Universities, 70
Urban Transportation Assistance Program, 77
USSR, 59, 69

Vehicle Duty Remission Orders, 68
VIA Rail Canada Incorporated, 39-53:
competition to, from automobiles, 42
crewing practices, 43, 48, 51
equipment, 40-41, 46, 48*t*, 50. *See also* rail equipment
operating practices, 51
operational savings using new equipment, 46, 50

rail-passenger-system simulation
recommended, 50
passenger service on freight trains, 46
responsibility for, 11
its restricted revenue, 42,
small parcel service on BRCs, 52
working conditions of, 43
Volkswagon, 68
Volvo, 79*n*, 86

Wardair, 26
Western Pacific Airlines, 26
World car, 64-65, 67, 70

Opportunities in Canadian Transportation Committee

Chairman
Dr. J.J. MacDonald*

Members

Mr. Harold Snyder*

Mr. F.W. Anderson
Department of Economics
University of Regina
Regina, Saskatchewan.

Mr. P. Beinhaker†
Managing Director
IBI Group
Toronto, Ontario.

Mr. Mark Brenckmann
Associate Director
Technology Development
Transport Canada
Montréal, Québec.

Mr. Paul Martin
President
Canadian Steamship Lines
Montréal, Québec.

Mr. Nick Mulder
Assistant Deputy Minister
Stategic Planning
Transport Canada
Ottawa, Ontario.

Mr. H. Romoff‡
Assistant Vice-President
Corporate Development
Canadian Pacific Limited
Montréal, Québec.

Project Officers

Dr. Alan Blair (July 1978 to November 1980)
Dr. Sam Gelman (November 1980 to July 1981)
Dr. Julius Lukasiewicz (feasibility study, July 1977 to July 1978)

---

* Member of Council.
† Resigned 1980.
‡ Transferred to England, 1981.

Members of the Science Council of Canada

Chairman
Stuart L. Smith

Members
Martin Blais,
Associate Dean (Academic),
Faculty of Philosophy,
Université Laval,
Québec, Québec.

Roger A. Blais,
Director,
Industrial Innovation Centre (Montréal),
École polytechnique,
Montréal, Québec.

John Philipp Borger,
President,
Arctic Mackenzie Consultants Ltd.,
Edmonton, Alberta.

J. Lionel Boulet,
Director General,
Institut de recherche d'Hydro-Québec,
Varennes, Québec.

Donald W. Branigan,
Physician,
The Branigan Clinic,
Whitehorse, Yukon.

Donald A. Chisholm,
President,
Innovation and Development,
Northern Telecom Ltd.,
Mississauga, Ontario; and
Chairman of the Board, and President
Bell-Northern Research Ltd.,
Ottawa, Ontario.

E. Lawson Drake,
Associate Professor of Biology,
University of Prince Edward Island,
Charlottetown, Prince Edward Island.

Mary-Lou E. Florian,
Conservation Analyst,
British Columbia Provincial Museum,
Victoria, British Columbia.

Jean-Paul Gourdeau,
Chief Operating Officer,
Le Groupe SNC,
Montréal, Québec.

Donald W. Kydon,
Dean,
Faculty of Arts and Science,
University of Winnipeg,
Winnipeg, Manitoba.

John J. MacDonald,
Executive Vice-President,
St. Francis Xavier University,
Antigonish, Nova Scotia.

John S. MacDonald,
President,
MacDonald, Dettwiler and Associates Ltd.,
Richmond, British Columbia.

Frank W. Maine,
President,
Frank Maine Consulting Ltd.,
Guelph, Ontario.

Arthur J. O'Connor,
General Manager,
New Brunswick Power,
Fredericton, New Brunswick.

B.E. Robertson,
Professor of Physics,
University of Regina,
Regina, Saskatchewan.

Stefan Simek,
President,
Ferguson, Naylor, Simek,
and Clark Ltd.,
Yellowknife, N.W.T.

Harold L. Snyder,
Director of the Centre for Cold
Ocean Resources Engineering,
Memorial University of
Newfoundland,
St. John's, Newfoundland.

David Suzuki,
Professor of Zoology,
University of British
Columbia; and
Broadcaster,
Canadian Broadcasting
Corporation,
Toronto, Ontario.

Vaira Vikis-Freibergs,
Professor of Psychology,
Université de Montréal,
Montréal, Québec.

J. Malcolm Webster,
Associate Vice-President,
(Academic),
Dean (Graduate Studies),
Simon Fraser University
Burnaby, British Columbia.

J. Tuzo Wilson,
Director General,
Ontario Science Centre,
Toronto, Ontario.

Henry C. Winters,
General Manager, Sales,
Algoma Steel Corporation,
Sault Ste. Marie, Ontario.

C.T. Wolan,
Clinical Associate Professor of
Surgery, Urology,
Saskatoon, Saskatchewan.

A.H. Zimmerman,
President and Chief Operating
Officer,
Noranda Mines Limited,
Toronto, Ontario.

Publications of the Science Council of Canada

Annual Reports

First Annual Report, *1966-67* (SS1-1967)
Second Annual Report, *1967-68* (SS1-1968)
Third Annual Report, *1968-69* (SS1-1969)
Fourth Annual Report, *1969-70* (SS1-1970)
Fifth Annual Report, *1970-71* (SS1-1971)
Sixth Annual Report, *1971-72* (SS1-1972)
Seventh Annual Report, *1972-73* (SS1-1973)
Eighth Annual Report, *1973-74* (SS1-1974)
Ninth Annual Report, *1974-75* (SS1-1975)
Tenth Annual Report, *1975-76* (SS1-1976)
Eleventh Annual Report, *1976-77* (SS1-1977)
Twelfth Annual Report, *1977-78* (SS1-1978)
Thirteenth Annual Report, *1978-79* (SS1-1979)
Fourteenth Annual Report, *1979-80* (SS1-1980)
Fifteenth Annual Report, *1980-81* (SS1-1981)
Sixteenth Annual Report, *1981-82* (SS1-1982)

Annual Reviews

Annual Review, *1980* (SS1-1/1980)
Annual Review, *1981* (SS1-1/1981)

Reports

Report No. 1, **A Space Program for Canada,** July 1967 (SS22-1967/1, $0.75)
Report No. 2, **The Proposal for an Intense Neutron Generator: Initial Assessment and Recommendation,** December 1967 (SS22-1967/2, $0.75)
Report No. 3, **A Major Program of Water Resources Research in Canada,** September 1968 (SS22-1968/3, $0.75)
Report No. 4, **Towards a National Science Policy in Canada,** October 1968 (SS22-1968/4, $0.75)
Report No. 5, **University Research and the Federal Government,** September 1969 (SS22-1969/5, $0.75)
Report No. 6, **A Policy for Scientific and Technical Information Dissemination,** September 1969 (SS22-1969/6, $0.75)
Report No. 7, **Earth Sciences Serving the Nation – Recommendations,** April 1970 (SS22-1970/7, $0.75)
Report No. 8, **Seeing the Forest and the Trees,** 1970 (SS22-1970/8, $0.75)
Report No. 9, **This Land is Their Land...,** 1970 (SS22-1970/9, $0.75)
Report No. 10, **Canada, Science and the Oceans,** 1970 (SS22-1970/10, $0.75)
Report No. 11, **A Canadian STOL Air Transport System – A Major Program,** December 1970 (SS22-1970/11, $0.75)
Report No. 12, **Two Blades of Grass: The Challenge Facing Agriculture,** March 1971 (SS22-1971/12, $0.75)
Report No. 13, **A Trans-Canada Computer Communications Network: Phase 1 of a Major Program on Computers,** August 1971 (SS22-1971/13, $0.75)

Report No. 14, **Cities for Tomorrow: Some Applications of Science and Technology to Urban Development**, September 1971 (SS22-1971 14, $0.75)

Report No. 15, **Innovation in a Cold Climate: The Dilemma of Canadian Manufacturing**, October 1971 (SS22-1971 15, $0.75)

Report No. 16, **It is Not Too Late – Yet: A look at some pollution problems in Canada...**, June 1972 (SS22-1972 16, $1.00)

Report No. 17, **Lifelines: Some Policies for a Basic Biology in Canada**, August 1972 (SS22-1972 17, $1.00)

Report No. 18, **Policy Objectives for Basic Research in Canada**, September 1972 (SS22-1972 18, $1.00)

Report No. 19, **Natural Resource Policy Issues in Canada**, January 1973 (SS22-1973 19, $1.25)

Report No. 20, **Canada, Science and International Affairs**, April 1973 (SS22-1973 20, $1.25)

Report No. 21, **Strategies of Development for the Canadian Computer Industry**, September 1973 (SS22-1973 21, $1.50)

Report No. 22, **Science for Health Services**, October 1974 (SS22-1974 22, $2.00)

Report No. 23, **Canada's Energy Opportunities**, March 1975 (SS22-1975 23, Canada: $2.75, other countries: $3.30)

Report No. 24, **Technology Transfer: Government Laboratories to Manufacturing Industry**, December 1975 (SS22-1975 24, Canada: $1.00, other countries: $1.20)

Report No. 25, **Population, Technology and Resources**, July 1976 (SS22-1976 25, Canada: $2.00, other countries: $2.40)

Report No. 26, **Northward Looking: A Strategy and a Science Policy for Northern Development**, August 1977 (SS22-1977 26, Canada: $2.50, other countries: $3.00)

Report No. 27, **Canada as a Conserver Society: Resouce Uncertainties and the Need for New Technologies**, September 1977 (SS22-1977 27, Canada: $2.25, other countries: $2.70)

Report No. 28, **Policies and Poisons: The Containment of Long-term Hazards to Human Health in the Environment and in the Workplace**, October 1977 (SS22-1977 28, Canada: $2.00, other countries: $2.40)

Report No. 29, **Forging the Links: A Technology Policy for Canada**, February 1979 (SS22-1979 29, Canada: $2.25, other countries: $2.70)

Report No. 30, **Roads to Energy Self-Reliance: The Necessary National Demonstrations**, June 1979 (SS22-1979 30, Canada: $4.50, other countries: $5.40)

Report No. 31, **University Research in Jeopardy: The Threat of Declining Enrolment**, December 1979 (SS22-1979 31, Canada: $2.95, other countries: $3.55)

Report No. 32, **Collaboration for Self-Reliance: Canada's Scientific and Technological Contribution to the Food Supply of Developing Countries**, March 1981 (SS22-1981 32, Canada: $3.95, other countries: $4.75)

Report No. 33, **Tomorrow is Too Late: Planning Now for an Information Society**, April 1982 (SS22-1982 33, Canada: $4.50; other countries: $5.40)

Report No. 34, **Transportation in a Resource-Conscious Future: Intercity Passenger Travel in Canada**, August 1982 (SS22-1982 34, Canada: $4.95; other countries: $5.95)

Background Studies

Background Study No. 1, **Upper Atmosphere and Space Programs in Canada**, by J.H. Chapman, P.A. Forsyth, P.A. Lapp, G.N. Patterson, February 1967 (SS21-1 1, $2.50)

Background Study No. 2. **Physics in Canada: Survey and Outlook,** by a Study Group of the Canadian Association of Physicists, headed by D.C. Rose, May 1967 (SS21-1/2, $2.50)

Background Study No. 3. **Psychology in Canada,** by M.H. Appley and Jean Rickwood, September 1967 (SS21-1/3, $2.50)

Background Study No. 4. **The Proposal for an Intense Neutron Generator: Scientific and Economic Evaluation,** by a Committee of the Science Council of Canada, December 1967 (SS21-1/4, $2.00)

Background Study No. 5. **Water Resources Research in Canada,** by J.P. Bruce and D.E.L. Maasland, July 1968 (SS21-1/5, $2.50)

Background Study No. 6. **Background Studies in Science Policy: Projections of R & D Manpower and Expenditure,** by R.W. Jackson, D.W. Henderson and B. Leung, 1969 (SS21-1/6, $1.25)

Background Study No. 7. **The Role of the Federal Government in Support of Research in Canadian Universities,** by John B. Macdonald, L.P. Dugal, J.S. Dupré, J.B. Marshall, J.G. Parr, E. Sirluck, and E. Vogt, 1969 (SS21-1/7, $3.00)

Background Study No. 8. **Scientific and Technical Information in Canada, Part I,** by J.P.I. Tyas, 1969 (SS21-1/8, $1.00)
Part II, Chapter 1, Government Departments and Agencies (SS21-1/8-2-1, $1.75)
Part II, Chapter 2, Industry (SS21-1/8-2-2, $1.25)
Part II, Chapter 3, Universities (SS21-1/8-2-3, $1.75)
Part II, Chapter 4, International Organizations and Foreign Countries (SS21-1/8-2-4, $1.00)
Part II, Chapter 5, Techniques and Sources (SS21-1/8-2-5, $1.15)
Part II, Chapter 6, Libraries (SS21-1/8-2-6, $1.00)
Part II, Chapter 7, Economics (SS21-1/8-2-7, $1.00)

Background Study No. 9. **Chemistry and Chemical Engineering: A Survey of Research and Development in Canada,** by a Study Group of the Chemical Institute of Canada, 1969 (SS21-1/9, $2.50)

Background Study No. 10. **Agricultural Science in Canada,** by B.N. Smallman, D.A. Chant, D.M. Connor, J.C. Gilson, A.E. Hannah, D.N. Huntley, E. Mercer, M. Shaw, 1970 (SS21-1/10, $2.00)

Background Study No. 11. **Background to Invention,** by Andrew H. Wilson, 1970 (SS21-1/11, $1.50)

Background Study No. 12. **Aeronautics – Highway to the Future,** J.J. Green, 1970 (SS21-1/12, $2.50)

Background Study No. 13. **Earth Sciences Serving the Nation,** by Roger A. Blais, Charles H. Smith, J.E. Blanchard, J.T. Cawley, D.R. Derry, Y.O. Fortier, G.G.L. Henderson, J.R. Mackay, J.S. Scott, H.O. Seigel, R.B. Toombs, H.D.B. Wilson, 1971 (SS21-1/13, $4.50)

Background Study No. 14. **Forest Resources in Canada,** by J. Harry G. Smith and Gilles Lessard, May 1971 (SS21-1-14, $3.50)

Background Study No. 15. **Scientific Activities in Fisheries and Wildlife Resources,** by D.H. Pimlott, C.J. Kerswill and J.R. Bider, June 1971 (SS21-1/15, $3.50)

Background Study No. 16. **Ad Mare: Canada Looks to the Sea,** by R.W. Stewart and L.M. Dickie, September 1971 (SS21-1/16, $2.50)

Background Study No. 17. **A Survey of Canadian Activity in Transportation R & D,** by C.B. Lewis, May 1971 (SS21-1/17, $0.75)

Background Study No. 18. **From Formalin to Fortran: Basic Biology in Canada,** by P.A. Larkin and W.J.D. Stephen, August 1971 (SS21-1/18, $2.50)

Background Study No. 19, **Research Councils in the Provinces: A Canadian Resource,** by Andrew H. Wilson, June 1971 (SS21-1/19, $1.50)

Background Study No. 20, **Prospects for Scientists and Engineers in Canada,** by Frank Kelly, March 1971 (SS21-1/20, $1.00)

Background Study No. 21, **Basic Research,** by P. Kruus, December 1971 (SS21-1/21, $1.50)

Background Study No. 22, **The Multinational Firm, Foreign Direct Investment, and Canadian Science Policy,** by Arthur J. Cordell, December 1971 (SS21-1/22, $1.50)

Background Study No. 23, **Innovation and the Structure of Canadian Industry,** by Pierre L. Bourgault, October 1972 (SS21-1/23, $2.50)

Background Study No. 24, **Air Quality – Local, Regional and Global Aspects,** by R.E. Munn, October 1972 (SS21-1/24, $0.75)

Background Study No. 25, **National Engineering, Scientific and Technological Societies of Canada,** by the Management Committee of SCITEC and Prof. Allen S. West, December 1971 (SS21-1/25, $2.50)

Background Study No. 26, **Governments and Innovation,** by Andrew H. Wilson, April 1973 (SS21-1/26, $3.75)

Background Study No. 27, **Essays on Aspects of Resource Policy,** by W.D. Bennett, A.D. Chambers, A.R. Thompson, H.R. Eddy, and A.J. Cordell, May 1973 (SS21-1/27, $2.50)

Background Study No. 28, **Education and Jobs: Career patterns among selected Canadian science graduates with international comparisons,** by A.D. Boyd and A.C. Gross, June 1973 (SS21-1/28, $2.25)

Background Study No. 29, **Health Care in Canada: A Commentary,** by H. Rocke Robertson, August 1973 (SS21-1/29, $2.75)

Background Study No. 30, **A Technology Assessment System: A Case Study of East Coast Offshore Petroleum Exploration,** by M. Gibbons and R. Voyer, March 1974 (SS21-1/30, $2.00)

Background Study No. 31, **Knowledge, Power and Public Policy,** by Peter Aucoin and Richard French, November 1974 (SS21-1/31, $2.00)

Background Study No. 32, **Technology Transfer in Construction,** by A.D. Boyd and A.H. Wilson, January 1975 (SS21-1/32, $3.50)

Background Study No. 33, **Energy Conservation,** by F.H. Knelman, July 1975 (SS21-1/33, Canada: $1.75, other countries: $2.10)

Background Study No. 34, **Northern Development and Technology Assessment Systems: A study of petroleum development programs in the Mackenzie Delta-Beaufort Sea Region and the Arctic Islands,** by Robert F. Keith, David W. Fischer, Colin E. De'Ath, Edward J. Farkas, George R. Francis, and Sally C. Lerner, January 1976 (SS21-1/34, Canada: $3.75, other countries: $4.50)

Background Study No. 35, **The Role and Function of Government Laboratories and the Transfer of Technology to the Manufacturing Sector,** by A.J. Cordell and J.M. Gilmour, April 1976 (SS21-1/35, Canada: $6.50, other countries: $7.80)

Background Study No. 36, **The Political Economy of Northern Development,** by K.J. Rea, April 1976 (SS21-1/36, Canada: $4.00, other countries: $4.80)

Background Study No. 37, **Mathematical Sciences in Canada,** by Klaus P. Beltzner, A. John Coleman, and Gordon D. Edwards, July 1976 (SS21-1/37, Canada: $6.50, other countries: $7.80)

Background Study No. 38, **Human Goals and Science Policy,** by R.W. Jackson, October 1976 (SS21-1/38, Canada: $4.00, other countries: $4.80)

Background Study No. 39, **Canadian Law and the Control of Exposure to Hazards,** by Robert T. Franson, Alastair R. Lucas, Lorne Giroux, and Patrick Kenniff, October 1977 (SS21-1/39, Canada: $4.00, other countries: $4.80)

Background Study No. 40, **Government Regulation of the Occupational and General Environments in the U.K., U.S.A. and Sweden,** by Roger Williams, October 1977 (SS21-1/40, Canada: $5.00, other countries: $6.00)

Background Study No. 41, **Regulatory Processes and Jurisdictional Issues in the Regulation of Hazardous Products in Canada,** by G. Bruce Doern, October 1977 (SS21-1/41, Canada: $5.50, other countries: $6.00)

Background Study No. 42, **The Strathcona Sound Mining Project: A Case Study of Decision Making,** by Robert B. Gibson, February 1978 (SS21-1/42, Canada: $8.00, other countries: $9.60)

Background Study No. 43, **The Weakest Link: A Technological Perspective on Canadian Industry Underdevelopment,** by John N.H. Britton and James M. Gilmour, assisted by Mark G. Murphy, October 1978 (SS21-1/43, Canada: $5.00, other countries: $6.00)

Background Study No. 44, **Canadian Government Participation in International Science and Technology,** by Jocelyn Maynard Ghent, February 1979 (SS21-1/44, Canada: $4.50, other countries: $5.40)

Background Study No. 45, **Partnership in Development: Canadian Universities and World Food,** by William E. Tossell, August 1980 (SS21-1/45, Canada: $6.00, other countries: $7.20)

Background Study No. 46, **The Peripheral Nature of Scientific and Technological Controversy in Federal Policy Formation,** by G. Bruce Doern, July 1981 (SS21-1/46, Canada: $4.95, other countries: $5.80)

Background Study No. 47, **Public Inquiries in Canada,** by Liora Salter and Debra Slaco, with the assistance of Karin Konstantynowicz, September 1981, (SS21-1/47, Canada: $7.95, other countries: $9.55)

Background Study No. 48, **Threshold Firms: Backing Canada's Winners,** by Guy P.F. Steed, July 1982, (SS21-1/48, Canada: $6.95, other countries: $8.35)

Issues in Canadian Science Policy

Issues 1, September 1974 (SS21-1/1, $1.00)
Issues 2, February 1976 (SS21-2/2, Canada: $1.00, other countries: $1.20)
Issues 3, June 1976 (SS21-2/3, Canada: $1.00, other countries: $1.20)

Perceptions

Vol. 1, **Population Growth and Urban Problems,** by Frank Kelly, November 1975 (SS21-3/1-1975, Canada: $1.25, other countries: $1.50)
Vol. 2, **Implications of the Changing Age Structure of the Canadian Population,** by Lewis Auerbach and Andrea Gerber, July 1976 (SS21-3/2-1976, Canada: $3.25, other countries: $3.90)

Vol. 3. **Food Production in the Canadian Environment,** by Barbara J. Geno and Larry M. Geno, December 1976 (SS21-3/3-1976, Canada: $2.25, other countries: $2.80)
Vol. 4. **People and Agricultural Land,** by Charles Beaubien and Ruth Tabacnik, June 1977 (SS21-3/4-1977, Canada: $4.00, other countries: $4.80)